ON THE

FUNCTION OF DIGESTION;

ITS

DISORDERS, AND THEIR TREATMENT.

A TREATISE

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DISORDERS, AND THEIR TREATMENT.

BY

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Dedicated

TO

SIR DANIEL GOOCH, BART., M.P.,

AS A

MARK OF APPRECIATION OF A LONG-STANDING FRIENDSHIP;

IN

ADMIRATION OF HIS PERSONAL CHARACTER;

AND IN

GRATEFUL ACKNOWLEDGMENT OF THE MANY ACTS

OF DISINTERESTED KINDNESS RECEIVED

BY THE AUTHOR.

PREFACE.

A portion of the contents of this volume formed the substance of a part of my "Gulstonian Lectures," delivered at the Royal College of Physicians in 1862. The view that will be found to be advanced in explanation of the manner in which the stomach escapes undergoing self-digestion during life was first alluded to there, and afterwards formed the subject of a paper published in the 'Philosophical Transactions' for 1863.

At the end of the work reference is made to the employment of artificial digestion as a means of dissolving meat for producing an article of nourishment in which the nitrogenized alimentary principles are in a state ready for absorption.

35, Grosvenor Street,
Grosvenor Square;
July, 1867.

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GENERAL REMARKS

ON

DIGESTION AND INDIGESTION.

The purport of digestion is the preparation of food for absorption; and its performance as one of the functions of life is called for by the circumstance, that the fluid state forms a necessary condition for the accomplishment of absorption. In organisms belonging to the vegetable kingdom an absence of a digestive system is to be remarked, because their food, consisting, as it does, of inorganic principles diffused through the atmosphere and dissolved in the moisture percolating the earth, is already in a fit state for absorption by the leaves and roots—the absorbing organs of the plant. In some few animal organisms, also, for a similar reason, there is an absence of digestive apparatus. In the generality of animal beings, however, the food is of a nature to require preparation before it is susceptible of absorption. Hence the demand for digestion as one of the functions of animal life.

Digestion, in a limited sense, may be taken as signifying the phenomena that occur in the stomach and intestine immediately antecedent to absorption; but looked at comprehensively, the light under which it will be regarded in the following pages, the various

operations accessory to this final act are also included as parts of the process.

Now, the first steps to be taken towards the accomplishment of digestion are PREHENSION and INGESTION. Food must be secured and introduced into the mouth before it can be eaten and digested.

In the cavity of the mouth two operations are performed—MASTICATION and INSALIVATION: the one consisting of a mechanical reduction of the food to a more or less minute state of subdivision; the other, its incorporation with a secretion poured out by a set of glands specially provided for the purpose.

Thus much accomplished, the food is formed at the back of the mouth into a bolus, and then propelled, by the process of DEGLUTITION, along a canal formed by the pharynx above and gullet below, into the stomach.

Arrived in the stomach, one of the chief acts of the digestive process is performed, viz., CHYMIFICATION, or GASTRIC DIGESTION. The food is brought in contact with a fluid—the product of secretion of the organ—which is endowed with a strikingly energetic solvent power over certain of the alimentary principles. By the agency of this secretion a semifluid material is formed, called chyme, which constitutes the product of gastric digestion.

Having reached the state of chyme, the food passes from the stomach into the small intestine, where it becomes incorporated with various secretions, the general effect of which is to cause the transformation of the watery-looking chyme into a rich cream-like magma. This constitutes CHYLIFICATION or INTESTINAL DIGESTION. The term chylification, however, signifying the production of a chyle-like magma, as representing the

effect of intestinal digestion, may have suited the older physiologists; but with the knowledge that is now possessed it conveys a very imperfect notion, as will be subsequently seen in the following pages, of what is in reality accomplished.

With intestinal digestion is completed the actual digestive process. The resulting phenomena are two: ABSORPTION and DEFECATION. As the digested aliment is slowly propelled along the small intestine by its peristaltic movement, the villi, or little absorbing organs with which its surface is so thickly studded, pick out the nutritive elements and discharge them into the lacteals, by which set of vessels they are conducted into the circulatory system, to replenish its contents or compensate for the constant extraction that is going on for the growth and maintenance of the body. Those portions of the ingesta that escape digestion and remain unabsorbed are gradually urged along towards the outlet of the alimentary tract, and thence expelled as useless matter from the economy.

As long as a healthy state of the digestive organs exists, and the process of digestion is naturally performed, we have no knowledge from our feelings that anything is going on. We ought not indeed to be cognisant by any feeling experienced of having a digestive apparatus or a function of digestion to perform. Beyond a sense of comfort and satisfaction, there ought to be no sensation produced by the ingestion of a meal at its appropriate time. Such in a perfect state of health also applies to all the functional operations of the body. Each and every one of them should be performed without our being made specially aware that either of them is being carried on.

If, instead of a sense of comfort and satisfaction, a state of uneasiness follows the ingestion of a meal, it may be taken either that the amount of food consumed has been beyond the natural limit—beyond what the natural digestive powers are equal to digesting; or that the digestive organs are not performing their work in a natural way. Indigestion or dyspepsia is said to exist when digestion fails to be performed in a healthy manner. The deviation from health may amount only to a slight sense of oppression, weight, or distension; or it may consist of one or more of the various manifestations of deranged action treated of in the following pages.

Digestion, as has been mentioned, consists of a series of operations, some of which constitute only accessory, whilst the others form the essential parts of the process. Now, it is only to deranged action having reference to the latter that the terms indigestion and dyspepsia apply. There may be a defective performance of an accessory operation which may lead to indigestion, but such defect does in itself fall within the range of meaning of the term. Defective mastication, for example, may lead to indigestion, but no one looks upon imperfect mastication as constituting a form of indigestion. So in defective deglutition there is a deranged performance of one of the operations of the digestive process—a derangement whereby the accomplishment of digestion may be more or less frustrated; but no one classifies dysphagia under the head of indigestion.

Looking at indigestion, then, which is thus limited to derangements connected with the accomplishment of the ultimate operations of the digestive process—in other words, to derangements connected with the

performance of gastric and intestinal digestion—the symptoms that may be observed are numerous and diverse. They fall, however, under three categories, being all referable either to (1) perverted sensibility, (2) perverted muscular action, or (3) perverted secretion.

The divers symptoms belonging to indigestion may be encountered, either singly or variously combined, in different cases. Sometimes they occur under such a form as to appear more like individual affections than symptoms of a general disorder.

The symptoms, also, produced by indigestion are not confined to symptoms of derangement of the digestive function only. The disordered state existing may, through reflex influence, affect other parts, and so lead to the occurrence of deranged actions elsewhere. And such is the range of sympathy that exists between the digestive organs and other parts, that the functional disturbances forming occasional concomitants of dyspepsia are almost as multifarious as those belonging to hysteria. The brain, heart, lungs, liver, kidneys, and skin, all, may betoken sympathy with a deranged state of the digestive organs; and so closely do the sympathetic disturbances produced sometimes simulate the phenomena of primary disease in the part affected, that close attention is often required to discriminate the difference.

There is no complaint that the physician is so frequently called upon to treat, in one shape or another, as that of indigestion; and this arises from the nature of the position the digestive organs occupy. As with other maladies, indigestion may be due to an inherited weakness of the organs, or to some other internal cause; but in by far the majority of instances it is by an influence

of an external nature that the complaint is brought on. Errors in eating and drinking form undoubtedly the most fruitful source of the complaint; and looking at the quantity and quality of the articles that are often put into the stomach—looking at the unnatural mode of living so common around us—the wonder is that the digestive organs escape being morbidly influenced by the unnatural circumstances to which they are exposed as freely as they do. By overtaxing the digestive powers a disordered state of the digestive organs may be brought about, just in the same manner, as is well known, disordered states of the brain and vocal apparatus are brought about by over-mental application and over-exercise of the voice.

It has been mentioned that, besides hereditary disposition, there are other internal conditions to which dyspepsia may be attributable. As various functional disturbances arise from derangement of the digestive organs, so a disturbance of the function of digestion is produced by derangements existing elsewhere. Digestion is the result of the exercise of a power dependent upon the action of certain secretions. Now, the production of these secretions is a vital operation, and is subject therefore to the general state as to health and vigour that may happen to exist. Under a seriously deranged state of the system, with the functions of life generally disturbed, it is hardly to be expected that the secreting action of the digestive organs should continue unimpaired. The secreting power being at fault, defective digestion and its various concurrent phenomena follow as a consequence.

Pathology has not thrown much light upon the subject of dyspepsia. It is true structural change in the

organs is often met with to account for the manifestations of deranged action that have been observed; but cases frequently happen where strongly marked symptoms of dyspepsia have been remarked during life without there being, even under microscopic examination, any appreciable textural alteration discoverable after death. There is nothing, however, that should excite astonishment in this; for we might just as reasonably expect to find structural change in the muscles in every case of disordered muscular action as structural change in the digestive apparatus in every case of disordered digestion.

Whilst the several manifestations of deranged digestion separately considered in the present work call for their special measures of treatment, the fact that they form symptoms of a general disorder must, nevertheless, not be lost sight of. The case, in other words, requires to be looked at in its entirety—requires to be viewed comprehensively, instead of wholly confining the attention to this or that phenomenon which may happen to form the prominent symptom of complaint.

In the treatment of all cases of deranged digestion it is of the first importance to pay strict attention to the diet. One of the great objects in medical practice generally is to lighten, as far as can be done, the work of any part of the system that may show signs of impairment; and, upon this principle, the diet in disordered digestion should be such as to keep the work to be performed within the range of power that happens to exist for adequately performing it. The quality and quantity of the food, as well as the periods at which it is taken, must be properly regulated. Without this, other measures will be useless, and the treatment defeated.

PREHENSION AND INGESTION.

To secure our food and introduce it into the mouth form the first steps that must needs be taken towards the performance of digestion. On looking through the animal kingdom, various are the devices that are observed for adapting different organs to the discharge of these offices, according to the special circumstances that exist. In man, the hands and lips form the instruments respectively designed by nature for the operations of prehension and ingestion. The hand, it may be observed, is susceptible of application, under the direction of man's intellect, to a multiplicity of purposes besides that of prehension; but that prehension is its fundamental intention may be inferred from its constituting the primary use to which it is applied in the child. Before there is mental development or intelligence sufficient to prompt it to the execution of any other designed movement, an object placed within reach of the hand is almost sure to be grasped and carried to the mouth.

The existence of disease about the mouth may interfere with the accomplishment of ingestion, and so frustrate the due performance of digestion. As regards prehension, however, our social state renders it scarcely likely, although such may occur amongst the lower animals, for digestion to be defeated through physical defect implicating the performance of this part of the process.

MASTICATION.

Mastication is directed towards the reduction of our food to a minutely divided state, so that it may more readily yield to the digestive influence of the secretions with which it is subsequently brought in contact. Its purport is the same as the process of pounding in a mortar, to which the chemist subjects a solid substance that he desires to place in a favorable state for solution.

A preparatory act to digestion this comminution of food is in most animals effected in the mouth, or what may be styled the ante-chamber to the digestive passages; the teeth constituting the organs by means of which the process is accomplished. In many, however, as in the whole of the bird tribe and some other animals besides, no comminuting apparatus is met with in the mouth, but in its stead an organ, the gizzard, is found, which is carried some distance down along the digestive tract, and placed in the abdominal cavity.

Different varieties of teeth are provided for the different purposes to be fulfilled, and throughout the animal series a beautiful harmony can be traced between the general character they present and the nature of the food destined to be consumed. The principal varieties are the incisors, or cutting teeth; the canines, or tearing teeth; and the molars, or grinding teeth.

The incisors are placed in the front of the mouth, and are met with in their highest state of development

in the mammalian group of rodents, comprising animals such as the squirrel, rabbit, rat, mouse, &c. They here constitute true chisel-like instruments, and, in their construction and mode of growth, provision is made for the constant retention of a sharp, chisel-like edge.

The canines are situated just behind the incisors. They are pointed in form, and adapted for enabling secure hold to be taken of an object that has been grasped by the mouth. They are seen in their most characteristic state in the mouth of the lion, tiger, and other members of the carnivorous order.

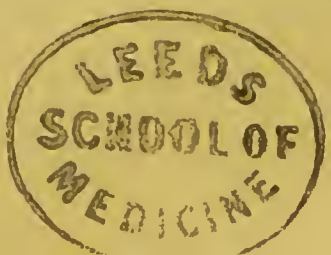
The molars are encountered at the back of the mouth. They present an expanded surface, adapting them for their office of pounding or crushing the food. It is in the herbivorous animal—as the elephant, horse, sheep, &c.—where this kind of tooth attains its most perfect grade of development; and here, unlike as with our own molars, the three component structures of the tooth—enamel, dentine, and crusta petrosa—which differ considerably in degree of hardness from each other, are arranged under the form of consecutive vertical plates, repeated series after series throughout the tooth. By such a plan of construction, the wear is rendered unequal, and the retention of a permanently uneven surface—a condition required for the process of reduction or grinding to be effectively performed—is secured. Corresponding with the plates of the softest material there exist depressions on the surface, as these yield the most readily to the effects of wear. For a converse reason, the hardest plates stand out as prominent lines or ridges. Thus, so perfect are nature's arrangements, instead of this com-

pound molar tooth of the herbivorous animal grinding down to an even surface, and thereby becoming a less effective instrument by use, its actual wear maintains it in a constant state of efficiency.

The above varieties of teeth are all of them present in man, each being found in a moderate state of development. The condition of man's dentition, as regards development of the several varieties of teeth, thus occupies an intermediate position, and furnishes one of the arguments to be adduced in favour of a mixed diet forming that which is designed by nature for his support.

We are provided with two sets of teeth during the course of life. The first or deciduous teeth are twenty in number, and in size and strength are adapted to the mouth and power of the muscles belonging to early years. As childhood is emerged from, these teeth are gradually shed, and replaced by a larger, stronger, and more numerous set. The permanent teeth are thirty-two instead of twenty in number; and in their general characters they conform to the increased size of the jaws and strength of the masticatory muscles belonging to later years.

An interval elapses between birth and the evolution of the first set of teeth; and for this period of life it happens that the sustenance provided for us by nature does not call for any performance of mastication. Thus the production of a liquid support by the female parent for the sustenance of her offspring during the earliest period of independent existence is in harmony with the edentulous condition of the mouth existing at this time. As teeth make their appearance, the mouth becomes fitted for the reduction of solid food. The evolution,



therefore, of these organs may be taken as affording a sort of physiological indication of the age at which the child should be weaned from its maternal support, and be supplied with solid matter as food. By the tenth to the twelfth month, from eight to twelve teeth have usually made their appearance in the mouth; and these would be perfectly meaningless with a continued subsistence upon a fluid diet. It may now be considered that some light kind of solid food is intended to be taken, because organs for its reduction have made their appearance, and are fairly progressing, in respect of the first or temporary set, towards completion.

From the belief—and it is a belief which certainly in the case of many cannot be pronounced as unfounded —that childbearing is held in check during the continuance of suckling, it is not uncommon amongst the poorer classes to meet with instances in which weaning is delayed till a much later period than the tenth or twelfth month. The impairment of health in the mother, and frequently in both mother and child, that such prolonged lactation is so often found to entail, shows that the dictates of nature upon this matter cannot be fearlessly disregarded. Some pretend to be ignorant of there being anything likely to be hurtful, or anything unnatural in the course adopted. Having ascertained from them that a fair number of teeth exist in their infant's mouth, the question may be put, by way of argument to bring home to them their mistake, whether it is thought that these teeth were placed there by nature for nothing, as nothing is required of them under sustenance upon the food which is being given.

Defective mastication, arising either from a habit of

too hastily eating—or bolting the food, or from a faulty condition of the masticatory organs, forms a frequent source of imperfect digestion. The more minute the state of subdivision to which the food is reduced in the mouth, the greater will be the facility with which it subsequently yields to the solvent influence of the secretions with which it is brought in contact. Food swallowed in solid portions may, by the resistance offered to digestion, act as a source of irritation, and occasion a deranged state of the digestive organs. All persons, but especially those of a dyspeptic habit—those possessing weak digestive powers—should deliberately masticate or thoroughly comminute their food in the mill that nature has provided for the purpose, before it is swallowed.

The state of perfection to which modern dentistry has risen leaves no room for complaint of inability to properly perform the function of mastication through the existence of a faulty condition of the machinery for the purpose. Whatever the imperfections and deficiencies that may arise in nature's dental apparatus, the resources of art are now-a-days found equal to meet the case.

INSALIVATION.

A fluid known as saliva is poured into the mouth, and incorporated with the food whilst it is being reduced by the process of mastication. This fluid is derived from certain large glandular organs lodged in the neighbouring locality, and a multitude of little glandular masses scattered beneath the mucous membrane surrounding the cavity of the mouth. The large glands exist in pairs, respectively symmetrical on the two sides. They form the two parotid, two submaxillary, and two sublingual glands.

The secretion of the parotid reaches the mouth through a duct, which perforates the mucous membrane of the cheek, and terminates opposite the second upper molar tooth.

The secretion of the submaxillary is poured into the mouth through a duct the termination of which may be recognised in the living subject upon the summit of a papilla to be seen by the side of the *frenum linguæ*, just behind the incisor teeth of the lower jaw.

The sublingual gland is provided with several small ducts, some of which open into the submaxillary duct, whilst the others directly pierce the mucous membrane lying over the gland along a ridge-like elevation which marks its position in the floor of the mouth underneath the tongue.

The scattered glands, each of which is provided with its own little duct opening upon the surface above, are named from their position: the labial, buccal, palatine, and lingual glands.

In ultimate structure, all these glands resemble each other. Each consists of a branched duct terminating in a series of vesicular dilatations formed of a homogeneous layer called *membrana propria*, or basement membrane. Within this vesicular extension of basement membrane is a lining composed of epithelial cells; and, on the other side of it, a vascular expansion consisting of capillary blood-vessels. The only difference between the glands is as to external form and size. In the larger glandular structures the lobules are aggregated around a common duct so as to form a compact circumscribed mass. In the others, the lobules are spread out over an extended surface, each forming an isolated mass provided with an independent little duct, through which the secretion is discharged directly into the mouth.

The view entertained with regard to the manner in which the process of secretion, in these, as in glands generally, is effected, is that from the plasma which escapes from the capillaries around the vesicular extremities of the duct, the epithelial cells within select certain materials—their appropriate elements of growth, which they afterwards give up, by rupture or solution of their cell-wall, to pass down through the duct, and form the product of secretion that flows from the gland. The variety existing in the composition of the different secretions depends upon the selective property of the cell, it being the province of the cell of one gland to select or appropriate certain materials;

and of the cell of another gland, other materials for its growth. The cells also, besides their selective endowment, must possess the power of exercising a transformative influence over some of their contents: organic principles being met with in the secretions that do not exist in the blood.

Mixed saliva, or the salivary secretion obtained from the mouth, presents itself as an opalescent, colourless or faintly bluish-white, tasteless, inodorous, and somewhat turbid and viscid liquid. Its sp. gr. is but little above that of water, usually ranging from 1004 to 1006. Its natural reaction has formed a subject of dispute amongst physiologists. The usual reaction encountered is that of alkalinity, but the test paper may show the existence of a neutral or even an acid state. This want of uniformity seems to have been made out to depend upon the relative amount of actual saliva and of mucous secretion that may happen to be present in the mouth at the time. The product of secretion of the salivary glands in a state of health is invariably alkaline, whilst the mucus, or product of secretion of the mucous membrane of the mouth, is on the other hand acid. Hence, if the mouth be examined at a period, as during a state of activity, when saliva is flowing from the salivary glands, an alkaline behaviour is the one that will be discovered. Taken, however, at a period of inactivity, no saliva happening to be present, the mucous secretion may cause an acid reaction to be encountered. The origin of a neutral state, after what has been said, follows without requiring any special explanation.

The pure secretions obtained direct from the salivary glands are perfectly transparent instead of opalescent

like mixed saliva. Although agreeing with each other in this respect, they strikingly differ as regards fluidity. Whilst, for instance, the secretion from the parotid is almost as thin as water, and that from the sublingual viscid in the extreme, that from the submaxillary is of an intermediate character.

Ptyaline is the name that has been given to the nitrogenized principle which forms the special organic constituent of saliva. Like diastase of the vegetable kingdom, this principle enjoys the property of acting as a ferment upon starch, and converting it into sugar. Amongst the saline ingredients of saliva is one, the sulpho-cyanide of potassium, which cannot be looked upon as otherwise than a strange chemical compound to be present in a normal product of the animal economy. It is easily recognised by its behaviour with a persalt of iron, and has not been encountered anywhere else in the system.

Eberle has suggested that the presence of a sulphocyanide in saliva is connected, like the morbid condition of the saliva in hydrophobia, with the existence of a particular state of the nervous system. To procure pure saliva, he says, it is necessary to collect it fasting. The following is an account of the plan he adopted upon himself:—After rising in the morning, coughing, spitting, and rinsing his mouth out with water to cleanse the mucous surface, he took a walk to put himself in a good humour. Returning home, he sat down and placed a basin in his lap, over which he held his head, allowing his saliva to flow into it as it was secreted, whilst he thought of something agreeable, particularly of some kind of food that he relished. The saliva thus secreted was, according to Eberle, perfectly

normal, and devoid of sulpho-cyanide. If, now, whilst it was thus being collected, he happened to think of anything disagreeable, particularly of his enemies, it immediately changed in character, and became charged with sulpho-cyanide. No physiologist, comments Bernard on this statement, besides Eberle, has had imagination enough to procure a like result.

From about fifteen to twenty ounces is the estimated average quantity of saliva secreted in man in the twenty-four hours. The determination, however, is a difficult matter to effect, and it cannot be considered that anything of a reliable nature is known upon this point. The amount of secretion produced will vary with the quantity and quality of the food ingested. When the mouth is in a state of quiescence, there is little or no saliva being poured into its cavity. Immediately, however, that food is ingested and mastication commenced, a stimulus is furnished which excites an abundant flow of secretion from the salivary glands. The drier the nature of the food, the longer is it delayed in the mouth, and the larger is the quantity of saliva required to convert it into a pulpy mass fit for being swallowed.

The facilities offered by the salivary glands for the performance of experiments upon the subject of secretion have been lately taken advantage of by Bernard, and much light has thereby been thrown by this physiologist upon the matter. His investigations have shown that the flow of secretion from a gland is as much a phenomenon under the control of nervous action as muscular contraction. In the case of the submaxillary gland particularly, he has not only established in the most conclusive manner that the flow of

its secretion takes place as the result of reflex nervous action, but has demonstrated the line of nervous continuity through which the effect is produced.

The saliva fulfils a variety of purposes in connection with the digestive process.

In the first place, by its presence in the mouth it aids the reduction of food by mastication. By its moistening action, also, it further facilitates deglutition, the food being converted into a soft, pulpy mass in the mouth, which can be subsequently propelled with ease through the throat and gullet into the stomach. The assistance afforded by the saliva to both mastication and deglutition may be realised by picturing to the mind the condition that would exist, with dry food in the mouth and no fluid secretion poured out to moisten it.

The food having been thoroughly incorporated with a fluid before its arrival in the stomach, will be much more easily impregnated and attacked by the solvent secretion produced by this organ. Thus, insalivation in an evident manner aids gastric digestion.

To gustation insalivation contributes assistance by furnishing the means for fulfilling one of the essential conditions required for the exercise of the sense. This special sense, of which the tongue forms the seat, informs us of the sapid qualities of bodies received into the mouth, and so guides us in the selection of food. For its exercise, contact and a state of solution form indispensable conditions. It is not only necessary that the substance to be tasted should be brought in contact with the surface endowed with sensibility, but that it should be in a state of solution so that it may penetrate and reach the gustatory

nerves. Now, the saliva contributes towards gustation by supplying a medium for dissolving substances that are not already in a state of solution when introduced into the mouth; and should the substance happen to be of such a nature as to resist solution, it will, as a consequence, be totally devoid of sapid properties.

It is the opinion of Bernard, that the parotids are specially associated with the function of mastication; the submaxillary glands, with that of gustation; and the sublingual, with that of deglutition.

In support of this view, the parotid secretion is distinguishable for its character of fluidity—a quality which specially fits it for the purpose suggested. It is also poured into the mouth in the neighbourhood of the grinding teeth, or just where grinding action is carried on; and, as shown by experiment upon the lower animals, and observation upon the human subject in cases of salivary fistula—or where, as the result of injury or disease, the parotid secretion finds an escape from its duct externally on to the cheek—its flow accompanies the process of mastication. In development, also, in the animal series, the parotids bear a relation to the state of perfection of the masticatory apparatus.

It has been stated above that the flow of secretion from the parotid glands is observed to bear a relation to, or to take place co-temporaneously with, the performance of mastication. The submaxillary glands respond, without any concurrence of mastication, to the simple application of a stimulus to the interior of the mouth. The impression derived from the contact of a stimulating agent with the surface of the tongue has been found, by experiment, to instantaneously excite, through the

medium of reflex nervous action, a flow of secretion from the submaxillary gland. The sight or even the idea of food, particularly in a hungry person, is sufficient to "make the mouth water;" and if attention be paid to the situation where the fluid enters the mouth, it will be found to correspond with the point of termination of the submaxillary ducts, viz. underneath the anterior part of the tongue.

The sublingual secretion, on account of its viscid consistence, is certainly well suited for besmearing the bolus of food about to be swallowed, with the view of facilitating its passage from the mouth to the stomach. As deglutition, also, is the finishing act of what is accomplished in the mouth, so the sublingual secretion has been experimentally found to be the last to make its appearance in respondence to a stimulus conveyed from the mouth. It is difficult, however, to conceive how a secretion escaping in the position the sublingual does, can be specially applied to the exterior of the food at the back of the mouth as it is about to be swallowed.

The actions that have been hitherto referred to are of a physical nature; it may now be inquired whether the saliva exerts any chemical or digestive influence over either of the constituents of our food. The nitrogenized, oleaginous, and saccharine principles give no signs of being acted upon by it. Starch, however, is rapidly transformed—at least by our own saliva, into sugar. Using a docoction of starch, and supplying a temperature equal to that of the living body, the effect is so rapidly produced that a few moments only are required for sugar in quantity to make its appearance.

Such is the nature of the transformative power with

which both mixed saliva and the pure secretions from the salivary glands are endowed in the case of the human subject. The saliva of all animals, however, does not possess a similar capacity. Neither the pure secretions from the different salivary glands, nor the admixture of these, in the case of the horse and dog, it may be mentioned, enjoy the power, when fresh, of transforming starch into sugar. It is true, after they have been kept a few days that they enjoy it; but in this, there is nothing special, the property being one that is common to organic fluids in general in a state of change. The mixed saliva of these animals, however, that has been derived from the cavity of the mouth is found to possess a transformative power, although of nothing like so strong a nature as that enjoyed by our own.

The presence of an acid interferes with the operation of the transformative endowment that has been just referred to, and the existence of a very small quantity is sufficient for the purpose. It follows, therefore, that directly the food reaches the stomach and is brought in contact with its acid secretion, all action of saliva upon starch must cease. Now, such being the case, and the food being delayed so short a time as it is in the mouth, it is questionable if the attribute under consideration can be looked upon as being of any real physiological import. There are other secretions, as will be subsequently seen, belonging to the digestive apparatus which enjoy in an energetic manner the power of digesting starch, or converting it into sugar; and with these other secretions, unlike as with saliva, the surrounding conditions happen to be in a high degree favorable towards the exercise of their power.

DEGLUTITION.

Deglutition constitutes the mechanical act by which the propulsion of the ingesta from the mouth into the stomach is effected. A canal exists for this purpose, consisting anatomically of two parts—the pharynx above, and the œsophagus, or gullet, below. Deglutition is hence spoken of as pharyngeal and œsophageal, according to the part in operation.

The pharynx, at least the alimentary portion of it, forms a funnel-like cavity which receives the food from the mouth. It gradually tapers as it extends down to its junction with the œsophagus. It is lined with mucous membrane, and provided with muscular fibres so grouped and arranged as to have the effect, when in action, of urging what has been received from the mouth down into the œsophagus.

The œsophagus forms a long, uniform, straight tube, which, beginning in the neck where the pharynx ends, passes just in front of the vertebral column down through the chest to terminate in the abdomen by becoming continuous with the stomach. Its mucous coat is thrown into a number of longitudinal folds —an arrangement evidently intended to allow of distension of the canal during the passage of food. In this mucous coat are a quantity of little glands, that pour out a secretion for the purpose of lubricating the

surface, and facilitating the accomplishment of deglutition. By muscular fibres arranged in two layers, one of which consists of a longitudinal, the other of a circular set, the tube is endowed with the power of performing a vermicular kind of movement, having the effect of exerting a propelling action towards the stomach.

Although a canal of only moderate dimensions, the œsophagus is susceptible of dilatation, so as to allow surprisingly large bodies to pass through it. A Mr. Alexander Wood gave to one of the Dr. Munro's, of Edinburgh, a glass ball, three inches in circumference, which had been swallowed by a child two years old. It passed, it is said, through the alimentary canal in two days, and did not give rise to a bad symptom. Substances, however, sometimes get fixed in the œsophagus, and may call for surgical aid to push them on, or, may be, to effect their removal by the operation of œsophagotomy. Pain, anxiety, and a sense of suffocation are the symptoms produced by the lodgment of bodies in the œsophagus. The danger of actual suffocation may render operative measures immediately necessary. Should this not be so, a little time may suffice, especially in the case of ordinary food, with the aid of the softening influence of the secretions poured out, to enable nature's unaided efforts to accomplish all that is required. False teeth form objects that sometimes get accidentally swallowed, and, from their complicated form, they may become so entangled in the throat as to render it exceedingly difficult for the surgeon to effect their removal.

A crossing of the food and air-passages takes place at the back of the mouth, which complicates the mechanism belonging to the process of swallowing, on

account of provision having to be made against the passage of food and fluids to the lungs instead of to the stomach. Advantages, however, of a more than commensurate nature are gained by the arrangement. In the first place, from the arrangement that exists, the expired column of air can be driven through the mouth and made subservient to the faculty of speech; and in the next, odorous emanations can find their way from the mouth into the nostrils, so that the organ of smell may act conjointly with that of taste in producing an impression upon the sensorium. A large number of impressions, indeed, which are commonly attributed to taste, are in reality chiefly due to smell—a fact that is rendered evident by chewing a piece of cinnamon, or some such aromatic substance, whilst the nose is held so as to prevent the passage of air into it from the mouth. The plan adopted by the nurse of holding the child's nose whilst nauseous medicine is being taken is evidently founded upon this circumstance. Common observation also sufficiently attests how much the sense of taste, as it is commonly understood, is blunted by the nasal mucous membrane being morbidly affected, as during the existence of a cold.

The means for preventing what is intended to reach the stomach from getting into the air-passages are very simple, and yet at the same time very effective The act of swallowing, in itself, secures the protection of the air-passages. The material to be swallowed is first forced by the tongue to the back of the mouth. Here it excites by reflex action, and therefore, whether the person is willing or not, the contraction of the muscles concerned in the accomplishment of the act. The tongue is carried backwards with what is to be

swallowed resting upon its surface, whilst the larynx is raised close up underneath. By this the epiglottis is folded over the upper opening of the larynx, and the entrance to the air-passages thereby closed. The material is then shifted from the tongue directly down into the pharynx, behind and clear of the larynx.

The epiglottis is doubtless specially provided for covering and protecting the opening of the larynx in the manner that has been described; but Magendie's and Longet's experiments on its extirpation in the lower animals, and the cases that have been met with of its destruction by ulcerative disease in the human subject, show that its presence is not absolutely necessary, and that deglutition can be performed without it, without anything occurring particularly amiss. The tongue, in fact, being carried backwards, and folded as it is over the larynx, and this, at the same time, being raised close up underneath, affords the required protection. In the animals experimented on, it was only with the swallowing of liquids that any inconvenience arose. This excited a convulsive cough, which may be accounted for by a little fluid, that would have been intercepted by the presence of the epiglottis, trickling along from the surface of the tongue into the larynx.

A couple of membrano-muscular folds—the posterior pillars of the fauces—are provided at the back of the mouth for the purpose of preventing what is swallowed being forced up towards the nose. They stretch from the soft palate obliquely downwards and backwards, and can be drawn together like a couple of curtains, so as to meet in the median line, and form a septum or partition between the upper—or nasal, and the lower—or alimentary part of the pharynx. As might be ima-

gined, a loss of structural integrity in these parts, arising, for instance, from ulcerative disease—a state that forms a frequent concomitant of secondary syphilis —entails a defect in the power of preventing the passage of food and drink upwards into the nose. Persons so affected complain that, unless they swallow slowly and with the greatest care, such an event is very prone to occur.

The act of pharyngeal deglutition forms a reflex-spinal phenomenon, and therefore requires no effort of the will to bring about its performance. Substances reaching the back of the mouth, or arriving within the range of distribution of the incident nerves belonging to deglutition, produce an impression which acts upon the associated nervous centre—the medulla oblongata —and draws forth an impulse having the effect of throwing the muscles concerned into that state of action which results in the performance of the process. When the will is in abeyance, as during sleep, &c., deglutition is as effectively performed, on the requisite stimulus being supplied, as when consciousness and voluntary power exist; and when the will is even operating in an adverse manner, if anything can be made to reach the back of the mouth, it must, *nolens volens*, be swallowed.

Although essentially a reflex-spinal act, and therefore taking place without the agency of, and even maybe, as just remarked, in opposition to the will; yet the will has power, within certain limits, of exciting its performance. We are all conscious of possessing the power, by an exercise of the will, of performing the act of swallowing without there being any food or drink in the mouth to swallow, and without even, it will be

found, if attention be given to the point, using our saliva instead for furnishing a physical stimulus to the parts. A few repetitions of the act, if continued in rapid succession, is, however, all that can be effected through the exercise of the will; the parts becoming then fatigued, and refusing to respond to the call that may be made upon them. With the stimulus of foreign matter, on the other hand, to act, as in swallowing in the ordinary way, deglutition may be rapidly repeated over and over again without the slightest difficulty or sense of fatigue being experienced.

Everyday experience shows that when all the parts belonging to deglutition are in a state of structural and functional integrity, the security our air-passages enjoy from the intrusion of foreign matter is exceedingly complete; and it is well for our safety that it is so. It is true, it has sometimes happened, through the parts being taken as it were by surprise, that foreign bodies, as pieces of coin and so on, have dropped down towards the lungs; and the most serious consequences have in some cases arisen therefrom. The convulsive paroxysm of coughing which is sometimes brought on at the meal-table by "something going the wrong way," is usually, if not almost invariably, attributable to an attempt at laughing, coughing, or talking being made whilst there is food or fluid in the mouth. By the effort at inspiration, a small particle of food (a light crumb of bread is a particularly favorable substance for the purpose) or a little fluid shall happen to be drawn into the air-passages, or against the laryngeal surface of the epiglottis; and, although it may be immediately afterwards expelled, an urgent state of temporary dis-

composure is the result, on account of the exquisite sensibility with which the surface touched is endowed.

Should the energy of the nervous system have become blunted, as it is observed to do under approaching death, an impression upon the fauces may fail to excite that quick and perfect respondence of the muscles of deglutition which is required for the ensurance of our personal safety. Thus, a portion of what has been introduced into the mouth may chance to get into the respiratory passages and excite a fit of choking which is sufficient to extinguish the flickering spark of life. Persons, it should be remembered, in a dying state swallow but imperfectly; and, therefore, the utmost caution is required in giving them medicine and drink, lest a sudden issue be brought about by something that is being administered passing the wrong way.

DIFFICULTY OF SWALLOWING, OR DYSPHAGIA.

Although the object attained by the process of deglutition is an exceedingly simple one—namely, the transit of our food and drink from the mouth to the stomach—yet difficulties connected with its performance are not of uncommon occurrence, and these difficulties in some cases give rise to the most urgent and serious consequences. Dysphagia is the term applied to difficult deglutition; aphagia, when the condition amounts to an impossibility of swallowing. The seat of complaint may be located in the mouth, fauces, pharynx, or œsophagus; and the obstruction may be either partial or complete, and temporary or permanent. A permanent and complete obstruction cannot be long before it leads to death by inanition, unless, by operative means, an opening can be established direct into the stomach through which the sustenance required can be received. A variety of causes contribute to the production of dysphagia. They may be divided into mechanical and dynamic.

The mechanical causes are such as—congenital malformations of the mouth, throat, and œsophagus; inflammation of or structural changes in the tongue, fauces, pharynx, larynx and epiglottis, and œsophagus; obstruction of the passage by the projection of a

tumour, or the presence of a foreign body within; and its occlusion by pressure from without, as from the existence of a tumour, abscess, or aneurism in the neighbourhood.

Malignant disease, and the contraction following inflammatory action produced by swallowing a corrosive material, constitute, it may be said, the most common causes of mechanical dysphagia.

A remarkable case of obstruction of the passage by a growth projecting within is mentioned by Monro.* A polypoid excrescence grew from the upper part of the œsophagus, and extended down within the canal to the orifice of the stomach. On vomiting being excited, this growth was thrown up into the mouth, and reached as far as the front teeth; but it could hardly be retained for half a minute in this position, on account of the opening of the larynx being covered by it, and the breathing thereby stopped.

In the dynamic form of dysphagia, a perverted action—spasm or paralysis—of some portion or other of the muscular apparatus belonging to deglutition, constitutes the immediate source of the disorder. The perverted action, however, is dependent on a variety of pathological states, which may be either local or remote, as will be seen from what follows.

Difficulty of swallowing is one of the phenomena of hydrophobia and tetanus. Here the dysphagia depends upon a morbid functional condition of the nervous apparatus. Such a state of irritability exists, that an impression, which, under natural circumstances, would have led to an ordinary performance of the act of

* 'The Morbid Anatomy of the Human Gullet, Stomach, and Intestines,' by Alex. Monro, M.D., Edinburgh, 1811.

swallowing, throws the muscles, instead, into a violent and continued state of spasmodic contraction.

In structural disease of the *medulla oblongata*, the centre presiding over deglutition, as well as in structural disease of the neighbouring parts—whether consisting of central nervous matter, the enveloping membranes, or bone—more or less irregularity in the performance of swallowing may be looked for as a concomitant; and the occurrence of this symptom, in conjunction with other evidence of such disease existing, must be regarded as in the highest degree ominous of danger. Besides other modes of unfavorable termination, a patient so affected is under daily risk of being choked by a morsel of food becoming impacted in the throat from the imperfect manner in which deglutition is performed. A patient, for instance—to give a sketch from an actual case—shall be complaining of symptoms suggestive of disease about the base of the brain. An occasional difficulty in the proper performance of swallowing, an alteration of the voice, and some disturbance of the breathing, lead to the presumption that the *medulla oblongata* is in some way or other implicated. The patient is sitting at dinner, and is all of a sudden seized with a fit of suffocation, and dies before there is time for professional aid to be procured. At the *post-mortem* examination, a piece of meat is found lodged in the entrance to the larynx, and this by stopping the breathing has been the immediate cause of death. Cerebral disease is also found sufficient to account for the phenomena that transpired.

In a case that not long since fell under my observation, a paralysed condition of the muscles of the fauces, apparently resulting from cold, formed the cause of a

temporary defect in the power of properly performing the act of swallowing. The patient spoke in a guttural manner, and complained that when he swallowed liquids, unless he exercised great care in swallowing slowly, a portion got into and partly returned through his nose, thereby occasioning him great inconvenience. The case at first sight appeared like one of structural loss of the soft palate from ulcerative disease. On looking into the mouth, however, all the parts were found in a state of structural integrity; but the soft palate hung down from the roof in a flaccid manner, floating to and fro with the breath. Under a tonic treatment, a week or two's time sufficed to restore both voice and deglutition to their natural state.

Dysphagia from a paralysed state of the muscles of the fauces and pharynx sometimes comes on as one of the sequelæ of diphtheria. After a variable period of temporary convalescence from the primary affection, the patient begins to experience difficulty in swallowing, accompanied with an alteration of the voice. These phenomena are associated with loss of sensibility in the soft palate, and are followed by manifestations of impaired nervous power elsewhere. It has been suggested that these symptoms of paralysis consequent upon diphtheria are due to a peripheral alteration of the nerves of the primarily affected part, the effect of which is propagated to the spinal centre in the same sort of way as happens in the case of a wound that produces tetanus, and thence occasions by a reflected influence the train of phenomena that are observed.

The œsophagus may form the seat of affection in dysphagia arising from both spasm and paralysis.

Dr. Monro* records a striking and well-authenticated case of dysphagia arising from spasmodic stricture of the œsophagus. The patient, a man 45 years of age, had been the subject of occasional fits of dyspepsia. At first he only experienced an occasional slight difficulty in swallowing, attended with pain about the middle of the sternum. At breakfast one day he observed, on attempting to swallow some bread with his tea, that it stopped in his gullet for a few seconds. A rumbling noise, as if from the discharge of wind, was then heard, and immediately afterwards the food passed on into the stomach. A probang being introduced, its progress was stopped when about half-way down the œsophagus, and with a large bougie a stricture was distinctly felt. Relief was obtained; but, after an attack of quinsy which subsequently arose from exposure to cold, the dysphagia returned, and it was found impossible to introduce even the smallest instrument. His symptoms, however, in the course of a few days remitted, and the probang passed as before. Evidence of gastric disease then showed itself, and in a few months' time the patient died. Ulcerative disease was found in the stomach, but its cardiac orifice was perfectly free, and not the slightest sign of structural mischief was to be discovered in any part of the œsophagus.

Dysphagia from spasm of the œsophagus is distinguished from dysphagia the result of organic disease by its mode of accession, which is more or less sudden, and by the remissions which frequently occur. In dysphagia from organic constriction, the invasion is slow, and the difficulty steadily increases. Still, it

* Op. cit.

must be borne in mind that the existence of organic disease often excites more or less spasmodic contraction, and thus partial remissions may be observed in the case.

When the spasm affects the upper part of the tube, attempts at swallowing are quite or nearly quite ineffectual, the substances taken being at once rejected. When, on the other hand, it occurs in the lower part, swallowing may be apparently accomplished by the upper part yielding, and retaining for awhile what has been taken. Under such circumstances, however, great distress is experienced until the substance has either passed on or been rejected. A case quoted by Monro shows the extent of yielding in the upper part of the œsophagus that may thus take place from constriction of the passage below. The case was one of organic constriction, and therefore the obstruction was of a constant or permanent nature. The capacity for yielding became such, that the patient could retain nearly a pint of nutritious liquid, consisting of eggs, milk, and sugar, for ten minutes, conversing with his friends during the while.

The form of dysphagia now under consideration is attended with pain behind the sternum, which is very much aggravated by attempts at swallowing. The sensation complained of may be that of soreness or of a sense of cord-like tightness behind the sternum or between the scapulæ, a dull pain referred to the course of the œsophagus, or an impression as of a foreign substance lodged within it. It is especially in the hysterical and hypochondriacal dispositions that this spasmodic affection occurs, and various are the exciting causes that lead to its development. In the *globus hystericus* which

forms so frequent a concomitant of hysteria, a reversed spasmodic action of the œsophagus may be looked upon as constituting the cause of what is felt.

Instead of spasm, dysphagia may result from paralysis of the œsophagus. The distinguishing features belonging to this form of dysphagia are, that small quantities of a substance may be swallowed with greater facility than large, and that the probang can be passed without obstruction into the stomach. Paralysis of the œsophagus constitutes one of the phenomena produced by division of the pneumogastric nerves in the neck. In one of my own experiments, where this operation had been performed upon a dog in connection with another object, I was surprised to find that a quantity of bread and milk placed before it was afterwards devoured, and seemed to be properly swallowed. On examining the animal, however, after the destruction of life a few hours afterwards, a large swelling was found at the back of the chest, which consisted of œsophagus distended with the bread and milk. The division had not been high enough up to affect the pharyngeal muscles, and so pharyngeal deglutition could be performed. The paralysed œsophagus had yielded, as the successive portions reached it, like a flaccid bag.

In the treatment of dysphagia, the practitioner must be guided by the nature of the cause upon which the affection depends.

Dysphagia arising from organic constriction is of the gravest possible import, and leaves but little room for hope.

In the spasmodic variety, attention should be given to the removal of any extraneous source of irritation

or debilitating influence that may be discovered. Sir B. Brodie relieved a female, who for three years had been subject to dysphagia to an extent that prevented her from being able to swallow solids, and liquids only with great difficulty, by the removal of some internal hæmorrhoidal tumours, which, from time to time, had caused considerable hæmorrhage. The general means to be tried consist of cathartic, sedative, and antispasmodic enemata; and mild aperients, sedatives, and antispasmodics administered by the mouth; combined with or followed by a course of tonics. Swallowing cold or iced fluids slowly will sometimes overcome spasm. Should these measures fail, the occasional passage of a bougie should receive a trial.

In the paralytic variety, cases are recorded by Munro in which relief was obtained by the use of electricity.

Should the employment of the probang or bougie be resorted to, whether as a measure of treatment or of diagnosis, the utmost caution requires to be exercised in the process of introduction. Abercrombie mentions a case that was related to him in which the passage of a probang for dysphagia, under the idea of its being caused by stricture of the œsophagus, caused the rupture of an aneurism and almost instantaneous death. In another case, also mentioned by him, the probang ruptured an abscess, and led to the escape of an immense quantity of matter, which afforded immediate and permanent relief.

The nature of the case in this complaint may be such, that, for sustaining the patient, nutrient enemata require to be had recourse to. Where organic constriction is the cause of the dysphagia, and

especially when the disease is of a non-malignant character, as particularly in the constriction resulting from the swallowing of a corrosive agent, the question of making an artificial opening into the stomach for the introduction of food may be entertained and put before the patient, all other measures having failed in affording relief, and death from starvation being the only prospect without the operation.

GASTRIC DIGESTION.

The stomach constitutes that part of the digestive apparatus in which the food undergoes the most marked change that occurs throughout the digestive process. The effect of gastric digestion is to dissolve and chemically transform certain principles of our aliment, and to reduce the mass of food to a semi-liquid condition, it being when so reduced spoken of as constituting chyme.

The organ in which this process takes place is an elongated pouch-like receptacle formed by a dilatation of the alimentary tract immediately below the œsophagus. It is placed in the upper part of the abdominal cavity, and extends across from the left side, at which the œsophagus enters it, to the right, where it terminates in the duodenum, or first portion of the small intestine. A constricted orifice, surrounded by a band of sphincter fibres—the pyloric valve—separates the two, and, under natural circumstances, allows only digested or semi-fluid matter to pass. A few sphincter fibres also exist around the other or cardiac orifice of the stomach, and serve by their contraction, whilst chymification is going on, to prevent the reflux of food into the gullet.

Belonging to the coats of the stomach is a layer of muscular fibres of the simple or unstriped kind, which spread in certain different directions over the organ.

The action of these muscular fibres is, by a slow vermicular kind of movement, to produce an orderly circulation of the food in the cavity of the stomach. The muscular coat thus aids in the reduction of food by promoting its admixture with the solvent secretion poured out from the glandular follicles belonging to the mucous coat. Through the friction also to which the fragments of food are subjected by the movement performed, their superficial portion is removed as fast as it is softened by digestion, and so the portion below is progressively exposed until a disappearance of the fragment results.

The circular fibres towards the pyloric extremity of the stomach, which form the most developed portion of the muscular coat, and constitute a layer of very great thickness in the stomach of the pig, may be regarded, it seems to me, as specially intended for exerting a compressing action that shall have the effect of squeezing out from the digesting mass its fluid or digested part, this being permitted to pass through the pylorus, whilst the solid or non-digested portion continues to be returned till the process is complete.

The innermost or mucous coat is the most important of all the tunics of the stomach; for it is to this that the characteristic attribute of the stomach is owing, it being here that the glandular apparatus is situated which gives to the organ the solvent power it enjoys. When the stomach is empty, the mucous membrane, which is then in a loose state, is thrown into a number of rugose folds, that are observed to take more or less of a longitudinal course. These are the rugæ of the stomach, and, being only inflections caused by the contraction of the muscular coat, they

become entirely obliterated when the organ is in a distended state. The mucous membrane forms a thickish layer of a soft though compact consistence. Its colour varies according as the organ is in a state of functional quiescence or activity. In the former it is of a pale pink, whilst in the latter it deepens to a bright reddish hue from the increased vascularity that exists.

The mucous membrane of the stomach, like other mucous membranes, structurally consists of a superficial epithelial layer, the cells of which are of the columnar-shaped variety, and a deeper part called chorion, which is made up of two layers—a layer of basement membrane above supporting the epithelium, and fibro-vascular tissue beneath. It is in the substance of the chorion that the glandular apparatus belonging to the stomach is placed.

It has been somewhat recently discovered that some muscular element enters into the composition of the deeper stratum of the mucous membrane. This is quite independent of the layer of muscular fibres forming one of the tunics of the organ. The use suggested that the muscular element fulfils in this situation is to empty the glandular tubules of their secretion.

The apparatus for the production of the gastric juice consists of a multitude of little simple glandular tubes, called the gastric follicles. They dip down vertically into the mucous membrane, and are packed closely together side by side. When the free surface of the mucous membrane immersed under water is examined with a low magnifying power by reflected light, it is seen to be everywhere marked with more or less circular openings. These are the orifices of the gastric follicles. They give to the surface a

sieve-like appearance. The intervening ridges contain a rich plexus of capillary blood-vessels, which in an injected specimen are found to map out the surface in a very orderly manner. Towards the pyloric end of the stomach, these ridges send up little projecting processes that may almost be compared in appearance to rudimentary villi.

The gastric follicles consist of simple tubular involutions of basement membrane lined with epithelium. The length of the tubes is on an average about the $\frac{1}{25}$th part of an inch; their diameter, about the $\frac{1}{350}$th of inch. Their length and breadth are greater at the pyloric than at the cardiac end of the organ. Below, they terminate in rounded and slightly enlarged closed extremities. It is difficult, however, to say if all the tubules present this simple termination. There is often a pouch-like disposition observable at the lower extremity of a tube; or, sometimes an appearance of a tube subdividing into two or three terminal extremities. It is possible that these appearances may be illusory, and in reality due to the effect of manipulation or chance superposition of tubules.

The gastric follicles are imbedded in a matrix of areolar tissue and the muscular element referred to, and are closely surrounded by blood-vessels, which form a plexus around them, in coursing upwards between them to the capillaries at the surface.

Towards the free extremity, the gastric tubule is lined with the same kind of epithelium as that which covers the surface of the stomach, viz. the columnar-shaped variety. Lower down, the epithelium is of the glandular kind, the cells being more or less round or spheroidal in shape.

These follicles, looked at individually, may from their minuteness appear insignificant; but directly the immense number of them that exists is taken into account, a proper idea of their significance is obtained. By counting the number of orifices existing in a given space, and reckoning for the whole extent of surface presented by the mucous lining of the stomach, it has been computed by Sappey that there are upwards of five millions of follicles in an average-sized human stomach.

The anatomical arrangement that has been described is the one which recent observation has disclosed as belonging to the human stomach. It does not agree, however, with the description that used to be given, which was drawn from the condition existing in the dog, where the internal surface is marked all over with irregularly hexagonal-shaped pits or depressions known by the name of the gastric alveoli. These gastric alveoli met with in the dog are lined, like the surface of the stomach, with columnar epithelium, and are usually found filled with mucus. It is into the bottom of them that the gastric follicles open, there being clusters of about four or five belonging to each.

Besides the open glandular tubules that have been referred to, closed sacs, corresponding in character, situation, and contents with the solitary glands of the intestine, are frequently to be recognised. It appears that they are not invariably present; at all events, it is not always possible to find them. When present, they are scattered more or less completely throughout the stomach, but are most numerous at its pyloric end. They are more frequently to be found in the stomachs of infants and children than in those of

grown-up persons. Nothing is known with regard to the purpose fulfilled by their presence.

The stomach is an exceedingly vascular organ. One of the three divisions of the cœliac axis is specially set apart for distribution to it, and a further supply of blood is given to it from each of the other two divisions.

The capillaries of the mucous membrane are derived from the ramifications into which the arteries split up in the sub-mucous tunic, or the layer of areolar tissue existing between the mucous and muscular coats. Capillaries proceeding from these ramifications enter the mucous membrane below, and run up between the secreting tubules, around which they form a plexus, towards its free surface. Arrived at the surface, these intertubular capillaries, instead of at once throwing themselves into veins, give origin to the much closer and more capacious set of superficial capillaries which map out and surround the orifices of the gastric tubules. From this latter set, veins arise and pass down between the tubules. This disposition of the intertubular and superficial sets of capillaries of the stomach I believe to contribute towards the security of the organ from self-digestion, in a manner that I shall subsequently point out when referring to the means by which I consider the stomach is enabled to resist undergoing digestion itself during the progress of digestion in its interior.

The veins which collect the blood that has traversed the stomach form a part of the portal system. The blood, therefore, returning from the stomach, is transmitted to and passes through the liver before it reaches the systemic veins.

A nervous supply is given to the stomach from both the cerebro-spinal and sympathetic systems. Branches

are distributed to it from the pneumogastrics; and filaments derived from the large ganglia situated in front of the vertebral column, forming the sympathetic centre connected with the chylo-poietic organs, reach it by coursing in an intricate plexiform manner along its arteries.

Experiment shows that the muscular coat is unquestionably susceptible of being influenced by impressions travelling along the pneumogastrics. Section of these nerves provokes vomiting, if food is contained in the stomach at the time of the operation; and their galvanic irritation in the recently killed animal visibly throws the stomach into an excited state of movement.

It has formed a debated point, whether or not section of the pneumogastrics stops the secretion of gastric juice. It seems that at first the process of secretion is interfered with; but it is evident, beyond all dispute, that gastric juice must be afterwards secreted; for it has been found that digestion can be subsequently carried on, although, it is true, with less energy than under natural circumstances.

Little or nothing of a positive nature has been ascertained about the influence exerted by the sympathetic upon digestion and the stomach; but it may be premised that it is in an important manner connected with the process of secretion.

The most erroneous ideas formerly prevailed about the nature of gastric digestion. Réaumur and Spallanzani were the first to show that the reduction of food in the stomach is due to the influence of a solvent fluid poured out from the walls of the organ. These experimentalits caused animals to swallow perforated metal tubes and balls containing food, and found that the

food, notwithstanding its position, underwent digestion and was removed. They also introduced pieces of sponge in their perforated tubes and balls; and on withdrawing them, after they had been in the stomach a little while, by means of a string attached, they obtained some of the gastric secretion. This they experimented with, and found that they could get digestion performed outside the stomach. But Spallanzani further experimented upon himself. Swallowing some small perforated wooden tubes containing food, he afterwards excited vomiting, and was enabled to observe the effects that had been produced by his own gastric juice.

By these experiments, the prevalent notion of the day—namely, that digestion depended upon a compressing action exerted by the muscular fibres of the stomach—was dispersed. The reduction of food in the stomach had been hitherto looked upon as effected by a process analogous to that by which reduction is accomplished in the gizzard of the bird. The gizzard, however, is not the homologue of a stomach: it is simply a triturating and not a digesting organ, and occupies in reality the place of the masticating apparatus of the mammal.

For much of the information we possess regarding the precise phenomena of digestion, we are indebted originally to the advantage that was taken of a rare opportunity that presented itself of watching what occurred in the interior of the living stomach of an individual who had met with a gunshot accident that left a permanent opening leading direct from the surface into the cavity of the organ. Since the occurrence of this case, an artificial opening has been made into the stomachs of the lower animals, and experi-

ments thereby performed which have confirmed and extended the knowledge previously obtained.

Alexis St. Martin is the name of the person referred to, whose case furnished the opportunity, which was taken advantage of by Dr. Beaumont, a surgeon in the United States Army, for conducting the researches from which issued the first complete account of the process of gastric digestion.

In June, 1822, Alexis St. Martin, a Canadian by birth, and at the time about eighteen years of age, received a charge of duck-shot in his left side, from the accidental discharge of a gun, the muzzle of which was not more than a yard off. The charge entered his side from behind, and passed in an oblique direction forwards and inwards,—"literally," it is stated, "blowing off integuments and muscles of the size of a man's hand, fracturing and carrying away the anterior half of the sixth rib, fracturing the fifth, lacerating the lower portion of the left lobe of the lungs and the diaphragm, and perforating the stomach."

From this extensive injury the young Canadian, miraculously enough, soon became restored to a perfect state of health. The wound healed, with the exception of the opening made into the stomach, which resisted every measure to close it. A compress and bandage had at first to be applied to retain the food in the stomach; but afterwards a fold of mucous membrane came down into the opening, which, in a valvular manner, closed it from above, so as to dispense with the necessity of any external appliance to prevent the escape of what had been taken. "This valvular formation," says Beaumont, "adapted itself to the accidental orifice so as completely to prevent the efflux of the

gastric contents when the stomach was full, but was easily depressed with the finger."

Such was the case upon which Dr. Beaumont's experiments and observations on digestion were performed. Commencing in 1825, his investigations were continued, with intervals of interruption, till the publication of his work 'On the Gastric Juice and the Physiology of Digestion,' in 1833.

To obtain gastric juice, Dr. Beaumont introduced a gum-elastic catheter for a distance of five or six inches into the empty stomach. The presence of the catheter excited a flow of secretion from the glandular follicles, and soon it began to escape through the catheter. At first it issued in drops, but afterwards in an interrupted, or sometimes a continuous, stream. Moving the catheter about in the stomach increased the rapidity of the flow. The quantity of gastric juice ordinarily obtained at a time was from four drachms to one and a half or two ounces. Its extraction was generally accompanied with the peculiar sensation known as sinking at the pit of the stomach, and with some degree of faintness, which rendered it necessary to stop the operation. That the stomach and health of Alexis St. Martin did not suffer under the experiments performed, is shown by the statement that the last series was continued for four months; and that, although different objects, such as food, drinks, gastric juice, chyme, elastic catheters, thermometer tubes, &c., were being introduced or taken out almost daily, and sometimes hourly, he continued during the time unusually plethoric and robust.

Another case of a similar description to that of St. Martin has since occurred, and been made the subject

of research by Bidder and Schmidt. Their experiments were continued for a period of about eight weeks. The subject of this case was a woman, in good health, who had had the unnatural opening in the stomach for about three years.

The case of Alexis St. Martin, and the fruitful account to which it was turned by Dr. Beaumont, doubtless suggested to physiologists the designed production of gastric fistula in the lower animals. Bassow in Russia, and Blondlot in France, applied themselves about the same time, and evidently independently of, or unknowingly to each other, to the subject, and succeeded in establishing a gastric fistula in the dog. The operation has since been successfully repeated by various physiologists. I have myself taken avail of the means afforded by it for personally verifying what is about to be said regarding the phenomena of gastric digestion.

It may now, then, be definitely asserted that gastric digestion is effected by the solvent agency of a secretion poured out by the glandular follicles that exist in the walls of the stomach. To the properties of this secretion I will first proceed to direct attention.

Gastric juice, separated from the mucus with which it is mixed as obtained from the stomach, is a limpid, transparent, and almost colourless liquid. It possesses a strongly acid with a slightly saline taste, and a faint peculiar odour which varies in character in different animals. Its specific gravity is very little above that of water. When pure, it occupies a remarkable position as an animal fluid in its power of resisting putrefactive decomposition. It may also be kept for a great length of time without losing its characteristic

physiological properties. Not only does it resist decomposition itself, but it further acts as an antiseptic agent upon other bodies, checking the putrefactive process, when this has commenced, in substances submitted to its influence. Its special physiological attribute is the power it possesses of dissolving the nitrogenized principles of our food; and for the enjoyment of this power investigation has shown that two ingredients, an acid and the organic principle called pepsine, form the agents essentially required. Neither of these will act alone; but, combined, they supply all that is wanted for the production of a solvent or digestive menstruum.

Pepsine constitutes a peculiar nitrogenized organic principle, yielded only by the mucous membrane of the stomach. It is soluble in water, but insoluble in spirit. Its aqueous solution, unlike one of albumen, is not coagulated by heat; but by exposure to a temperature above 140° the active properties of pepsine are destroyed, and it is reduced to a completely inert substance. It possesses by itself the power of curdling milk —a power that is enjoyed by no other neutral organic principle. This property is turned to practical account in the uses to which runnet—an article procured from the fourth stomach of the calf, and owing its virtue to pepsine—is applied.

It is to be noted that pepsine is always present in the mucous membrane of the stomach; not only, therefore, whilst digestion is going on, but during fasting, and even under the severest forms of disease. I have found it apparently as abundant and effective in the stomach of the dog after seventy-two hours' fasting, as at a period of digestion. I have also found that the

acidulated infusion of the mucous membrane of stomachs taken from the *post-mortem* room of Guy's Hospital, and derived from persons who had died from protracted disease, has possessed energetic digestive properties. With the stomachs that were examined, the following, for example, were the causes of death :— Typhoid fever, phthisis, apoplexy, lardaceous disease, lithotomy, ovarian disease, and heart disease with typhoid symptoms.

Pepsine procured from the stomach of the calf and pig has an extensive sale as a medicinal agent, being administered in dyspepsia and some other complaints, with the view of contributing assistance towards the performance of digestion. Seeing that pepsine happens to be always present in the mucous layer at the surface of the stomach, doubts may not unreasonably be entertained regarding the utility of, or the reality of any assistance to be derived from its administration. It may be admitted, however, as possible that in some cases the pepsine in the stomach may be deficient in quantity or defective in quality, and that service may be derived from its administration with the food : but for this to be the case, it stands to reason that the pepsine employed must be in an effective condition. Now, speaking from the examination of several specimens of pepsine procured from some of the largest pharmaceutical establishments in London, the bulk of that which is sold is totally devoid of any active property. Whether this arises from too much heat having been employed in its preparation, or from whatever cause, the fact remains that the chief portion of the pepsine sold and administered, being perfectly inert as a digestive principle, is destitute of any real value as an agent for affording assistance towards the perform-

ance of digestion.* Whatever benefit, therefore, has seemed to accrue from the employment of such a preparation, must have arisen from its influence on the mind rather than on the process of digestion.

One of the most striking characters of the gastric juice is its strong acidity. The nature of the acid has been variously stated by different authorities. Dr. Prout, who was the first to investigate the subject, arrived at the conclusion that the gastric juice contained a considerable quantity of free hydrochloric acid. Blondlot objected to Prout's method of analysis, and himself contended that the acidity is due, not to the existence of a free acid, but to an acid phosphate of lime. Tiedemann and Gmelin say that they have encountered the acetic and butyric acids. Some modern authorities have assigned the acidity to the presence of lactic acid. It is not impossible that these discordant statements may owe their origin to the gastric juice of different animals having been taken for examination. Altogether, the weight of opinion is in favour of the hydrochloric as being the acid which belongs to the gastric juice of the human subject. To account, however, for certain traits of behaviour that have been noticed, it has been suggested that the acid does not exist in a free state, but in combination with pepsine, which modifies its properties, and makes it in fact a new acid, to which the name of hydrochloro-pepsic acid has been given.

* In the "Gulstonian Lectures," vide 'Lancet,' April 25th, 1863, I mentioned the sources from whence I obtained the specimens of pepsine referred to. It is but justice to state that Messrs. Bullock & Reynolds' pig pepsine was found to possess very active properties.

Mean composition, from nine analyses, of gastric juice from the dog, free from admixture with saliva (Schmidt).

Water	973·062
Organic matter	17·127
Free hydrochloric acid	3·050
Chloride of potassium	1·125
Chloride of sodium	2·507
Chloride of calcium	0·624
Hydrochlorate of ammonia	0·468
Phosphate of lime	1·729
Phosphate of magnesia	0·226
Phosphate of iron	0·082
	1000·000

It is only at the period when gastric juice is required in the stomach, namely, whilst food is present to be digested, that it flows from the glandular follicles. During the empty state of the organ, its surface is besmeared with a transparent viscid mucus, which, with some frothy saliva that has descended from the mouth, constitutes its only contents. Test-paper applied may indicate a neutral or even an alkaline reaction. Immediately, however, that food is ingested, or any foreign body introduced, a stimulus is supplied which causes the mucous membrane to become turgid and more or less reddened from increased vascularity. Little limpid drops of fluid then exude from the surface like drops of perspiration from the skin. These limpid drops constitute the product of secretion of the glandular follicles. On being tested, they are invariably found to present a strongly acid reaction.

Formerly the gastric juice was described as being sometimes acid, sometimes alkaline. It is evident, however, that the mucus which the stomach contains during its quiescent state must have been mistaken for the special gastric secretion which is present only when digestion is going on, and which, as mentioned above, is invariably very strongly acid.

Observation has shown that the substance introduced into the stomach need not necessarily form an alimentary material to excite a flow of gastric juice from the follicles. The contact of a foreign substance of any description with the mucous surface affords the requisite stimulus for exciting secretion. The presence of the gum-elastic catheter in Dr. Beaumont's experiments formed a sufficient stimulus, and enabled him to draw off, as he did, pure gastric juice from Alexis St. Martin's stomach.

The quantity of gastric juice secreted cannot be looked upon as having been as yet even approximatively determined, but there is no doubt that it is large. According to Tiedemann and Gmelin, it varies with the stimulating character and digestibility of the articles of food ingested. The more difficult of digestion an alimentary substance, the larger the quantity of gastric juice that is poured out. Liquid food does not exert the same stimulating effect upon secretion as solid. It is said that alkaline materials excite in a special manner the flow of gastric juice; and, that it seems, on the other hand, to be diminished by acids. According to Corvisart, ice, very cold water, moderately strong alcoholic liquids, wines (especially Sherry and Bordeaux), strong coffee, and various aromatic and bitter vegetable infusions, excite with more or less energy

the secretion of a liquid possessing a high degree of digestive power.

In a febrile state of the system, as ascertained by Dr. Beaumont upon Alexis St. Martin, the secretion of gastric juice becomes greatly diminished or entirely suppressed. To quote Dr. Beaumont's words—"Drinks received are immediately absorbed, or otherwise disposed of, none remaining in the stomach ten minutes after being swallowed. Food taken in this condition of the stomach remains undigested for twenty-four or forty-eight hours, or more, increasing the derangement of the whole alimentary canal, and aggravating the general symptoms of disease." Such, it is well known, harmonises with the dictates afforded by the inclinations experienced, there being in the febrile state a repugnance for solid food, with a strong craving after liquids. The mistake of administering solid food in such a state is apparent. Should it, indeed, be taken, and vomiting, which is generally excited as a consequence, not happen to follow, it will remain as a load upon the stomach, and so form a source of irritation to the system.

Eberle was the first to obtain the clue that led to the discovery of the acting principles belonging to the gastric juice. Having ascertained that neither an acid nor an infusion of the mucous membrane of the stomach possessed any digestive power, he placed the two together, and immediately obtained a digestive or solvent menstruum. It is only the mucous membrane of the stomach that will yield the organic matter required, but any acid—mineral or organic—will serve for giving to the proper infusion digestive properties.

Gastric juice may thus be artificially prepared, all that is requisite being to combine the special organic

principle belonging to the mucous membrane of the stomach—pepsine—with an acid. For making artificial gastric juice, either prepared pepsine or the fresh or dried stomach may be used. If the prepared pepsine of the shops be employed, attention must be given to its being in an effective state; for, as already mentioned, the bulk of the pepsine sold is a perfectly inert and worthless material. Of good pepsine, ten grains to the ounce of water forms a sufficient quantity to produce an energetic digestive solution with the requisite addition of acid. If the fresh stomach be taken, the pulp scraped off from the mucous surface, or the mucous membrane itself cut off in pieces, must be infused in cold or tepid water for from twelve to twenty-four hours. The strained infusion is then to be treated with the acid, and an artificial digestive liquid is obtained.

The properly dried mucous membrane answers just as well for making the infusion as that of the recent stomach, and it has the advantage of keeping, so as to be ready for use at any time. I am in the habit of preserving and employing it for experimental illustration in my course of physiological lectures, and the following is the way in which it is prepared:—The stomach of the pig, as soon as possible after removal, is laid open and rinsed. The mucous membrane is then dissected off from the other coats, stretched out upon a light wooden frame, and dried before the fire, care being taken that it is placed sufficiently far off to secure its not being exposed to more than a moderate degree of warmth. In the course of a few hours it becomes thoroughly dried, and may be afterwards hung up and kept in any dry place. When required for use, it is cut into shreds and infused in water. The dried membrane may also

be ground to powder, and kept, and used in this form.

In my experiments on artificial digestion, I am in the habit of employing twenty drops of strong hydrochloric acid to the ounce for acidifying the infusion. This makes a very powerful digestive solution. Its effects are well exemplified by suspending in it the hind legs of a frog for three or four hours at a temperature of about 100°. The immersed portion will be found at the end of the time to be very strongly acted upon, if not completely dissolved. The frog having been killed, the hind parts are detached by division across the spine. The legs are then suspended in the liquid by a piece of thread. They form the best medium I know of for displaying the possession or non-possession of digestive power: being easy of digestion, and readily showing the slightest action that takes place. Used as a test, if there is no solution of the skin, or softening and separation of the muscles, after four or six hours' exposure to a temperature of about 100°, it may be concluded that the liquid operated on is devoid of digestive power.

Temperature influences materially the rate of digestion. The higher the temperature short of about 140°, the point at which the virtue of the nitrogenized organic principle—pepsine—is destroyed, the more rapid or energetic is the gastric juice in its action. At the ordinary temperature of the atmosphere, the effect is almost *nil*. A temperature of about 100°, or a little over, is that which in experimenting it is desirable to employ, thus imitating as near as possible the condition under which digestion is performed during life. Dr. Beaumont found, from numerous observa-

tions, that the temperature of Alexis St. Martin's stomach ranged between 98° and 102° when empty, and 99° and 103° when digestion was procceding.

For gastric digestion, then, it may be said that a liquid containing the special organic principle derivable from the mucous membrane of the stomach in combination with an acid, and the existence of a suitable temperature, form the essential conditions that are needed. If these conditions are supplied, it matters not, as far as the result is concerned, whether the process is carried on inside or outside the living body. Gastric digestion in itself is a purely chemical process. The only part that is dependent on vital action is the production of the organic principle, without which it cannot proceed. It is true, however, that the movements of the stomach afford a mechanical aid, and place natural under more favorable circumstances than artificial digestion.

Different theories have been propounded to account for the *modus operandi* of the gastric juice. By some it has been suggested that the gastric juice exerts its solvent action by what is called catalysis—to give a parallel —that it acts like spongy platinum in the acetification of alcohol. In opposition to this view, it is to be remarked that in changes produced by catalysis the catalytic agent itself undergoes no alteration, and does not become exhausted; whilst with the gastric juice, observation shows that a given quantity can only dissolve a certain amount of nitrogenized matter. Others have suggested that it acts as a ferment like yeast—that in its organic principle (pepsine) we have a changeable body, which is capable under the presence of an acid of inducing a state of change in the

nitrogenized constituents of our food, resulting in solution. Another suggestion is, that the pepsine is in combination with the acid of the gastric juice, so as to form a compound or conjugated acid which possesses solvent properties not enjoyed by the simple nor by any other acid. In the case of the human gastric juice, it would be the hydrochloric acid with which the pepsine is combined, the compound being styled the hydrochloro-pepsic acid.

Bone and metallic substances suffer attack by the gastric juice. For the animal part of bone, the organic principle and acid are required in combination; but the acid alone suffices for the solution of the earthy part. A neat experiment was performed by Sir Astley Cooper, showing the digestibility of bone, and the specimen resulting therefrom is preserved in the Guy's Hospital Museum. One side of a flat slip of bone was varnished over by him with a layer of sealing-wax, upon which he scratched out his name. Upon the other side he wrote his name in sealing-wax, leaving the surface otherwise free. The sealing-wax, a non-digestible material, was intended to protect the surface of bone lying underneath it. A dog was then made to swallow the slip of bone with a string attached to it, so that it could be afterwards recovered. After being allowed to remain in the stomach for some hours, it was withdrawn. Upon one side the specimen shows the name engraved, whilst upon the other the letters are seen standing out in relief.

Some remarkable specimens that are contained in the Museum of Guy's Hospital, and which were derived from the performances of a real knife-eater, who died in the hospital from the effects of his exploits, the

early part of the present century, show in a striking manner how strongly metallic substances are attacked by the digestive secretion. The history belonging to this man's case is of an interesting nature, and runs shortly as follows :—

John Cummings, an American sailor, whilst on shore with some of his shipmates in France, saw a mountebank entertaining an audience by pretending to swallow clasp-knives. After returning to the ship, and whilst under the influence of grog, Cummings boasted that he could swallow knives as well as the Frenchman. He swallowed his own knife first; and, his shipmates not being satisfied, he afterwards swallowed three others. Three out of the four knives were passed by him during the following two days : the other he never saw, nor did he ever experience any inconvenience from it. Six years later, whilst drinking with a party of sailors, he was tempted to boast of his former exploit, adding that he was the same man still. During the course of the evening he swallowed six knives, and on the following day eight more. This time vomiting and severe pain in the stomach ensued, and he was taken to the Charleston Hospital, where, according to his own nautical way of expressing it, "he got safely delivered of his cargo." Nine months afterwards, boasting again of his former exploits, he was driven into repeating his performances. He now paid dearly, however, for his folly, and ultimately became an inmate of Guy's Hospital, where he remained lingering for some time in a distressing state till he died. Whilst in the hospital, he wrote a narrative of his life, which, in his own handwriting, is preserved in the hospital museum. Altogether, the number of knives swallowed by him upon

various occasions amounted to at least thirty-five. Several portions of blades, springs, and handles of knives were found in a highly corroded state in his stomach after death. These, with some specimens discharged from him whilst alive, and likewise the stomach, which is in a contracted and corrugated state from the diseased condition that was set up, are deposited amongst the preparations of the museum.

The time required for food to be digested in the stomach varies with the nature and quantity of the materials taken, as well as with the state of the organ as to health. In the observations of Dr. Beaumont upon Alexis St. Martin, a moderate meal of meat, bread, &c. was ordinarily found to undergo digestion and to disappear from the stomach in from three to three and a half hours' time. As regards rate of digestion, however, a good deal depends on the state of subdivision in which the food happens to be on arriving in the stomach. In one experiment, Dr. Beaumont introduced through the fistulous opening into the stomach of his subject two ounces of underdone roast beef, tied to a piece of string to enable it to be withdrawn; and in four hours' time about half of it only was found to have been digested and removed. In dogs, where the food is hastily bolted, and a considerable quantity at a time devoured, I have found undigested remains in the stomach at the end of twenty-four hours, and even a longer period than this, after they have been fed upon a meal of tripe. With a solid mass, it is only at the surface that digestion can proceed; whereas with food reduced to a comminuted state, its intimate incorporation with gastric juice is throughout permitted, and so a more thorough exposure to the

digestive influence is brought about. It is not difficult to understand how minuteness of subdivision contributes towards expediting the process of digestion.

"From numerous trials," says Dr. Beaumont, "I am persuaded that moderate exercise conduces considerably to healthy and rapid digestion. The discovery was the result of accident, and contrary to preconceived opinions. I account for it in the following way. Gentle exercise increases the circulation of the system, and the *temperature* of the stomach. This increase of temperature is generally about $1\frac{1}{2}°$. . . . . Severe and fatiguing exercise, on the contrary, retards digestion. Two reasons present themselves for this: the debility which follows hard labour, of which the stomach partakes; and the depressed temperature of the system consequent upon perspiration and evaporation from the surface."

The influence that temperature exerts upon the process of digestion has been already alluded to. In the summary drawn from a large number of observations upon the temperature of Alexis St. Martin's stomach in different states as regards emptiness and repletion, and at different seasons of the year and periods of the day, Dr. Beaumont shows that the temperature is higher during digestion than fasting, and in both these states higher during exercise than repose. For example, with the stomach empty and the body in a state of repose, the temperature ranged between 98° and $100\frac{3}{4}°$, whilst during exercise it ranged between 100° and 102°; with the stomach full, the range of temperature observed was between 99° and 102° during repose, and during exercise between $100\frac{1}{2}°$ and 103°.

The practice now so common in luxurious life of eating ice-puddings at dinner and ices at dessert is not in harmony, however agreeable at the time it may be, with physiological principles. From well-ascertained facts, it may be positively asserted that lowering the temperature of the interior of the stomach whilst digestion is going on cannot fail to interfere with and retard the completion of the process. Drinking copiously of cold fluids must also exert the same effect as partaking of ice-puddings and ices. Upon one occasion, with the thermometer introduced into St. Martin's stomach whilst in an empty state, Dr. Beaumont noticed that the effect of drinking a quarter of a pint of water at a temperature of 55° was to occasion an immediate fall from 99½° to 70°. The temperature stood at this point for a minute and a half to two minutes, and then began very slowly to rise; but it was not until after half an hour had elapsed that it had risen again to 99°.

Alcohol is destructive of the power of the gastric juice by throwing down its pepsine in an insoluble state. It is easily shown by means of experiment outside the body, that the effect of the presence of a certain amount of alcohol is to prevent the process of digestion from being carried out. Now, the same must hold good with regard to digestion in the interior of the stomach; and thus is accounted for the vomiting that constitutes so common a consequence of a debauch, and also the fact that the food which has been taken is found to be rejected in an undigested state. The "petit verre" that is frequently taken after a heavy dinner, or to follow an indigestible article of food, is taken with the view of its affording assistance to digestion; and notwithstanding what has been said,

it is not incompatible that it should do so. It is quite consistent that a small quantity of spirit taken into the stomach may expedite digestion by its stimulating effect upon the glandular follicles, leading to an increased flow of secretion; whilst a larger quantity, by virtue of its chemical action on the secretion produced —by precipitating as it does its active organic principle, should exert exactly the opposite influence on the result.

The physical effect produced by gastric digestion upon the food is to transform it into a homogeneous semi-fluid material, which is spoken of as constituting chyme. In colour this product of gastric digestion—or chyme, varies according to the nature of the food from which it has been derived. It invariably presents a strongly acid reaction. As it is formed, it gradually passes through the pyloric orifice of the stomach into the duodenum.

With this physical change, a chemical action is exerted upon some of the constituents of the food: the nitrogenized group of alimentary principles forming the materials that yield to the chemical influence of the gastric juice. These the gastric juice converts, one and all, into a substance that has received the name of "peptone" from Lehmann, and "albuminose" from Mialhe. In their transformation into peptone or albuminose, the nitrogenized principles lose completely the original distinctive properties they possessed. The newly formed material, no matter from what source or from what nitrogenized principle it has been derived, presents the same chemical properties. It is soluble in acid, alkaline and neutral solutions, and is not precipitable by heat. Besides the possession of this marked

quality of solubility, it is further characterised by being endowed with great diffusibility—a property of the highest physiological importance for it to enjoy, enabling it, as it does, to pass by the simple physical principle of osmosis from the alimentary canal into the circulatory system. Upon reaching the circulatory system, this peptone or albuminose doubtless constitutes the pabulum or source from which the nitrogenized proximate principles of the blood are derived.

In respect of fibrine and gluten, it may simply be said that they are gradually dissolved by the agency of the gastric juice, the resulting solution containing albuminose.

Albumen in a state of solution is not, as is sometimes asserted, coagulated like caseine. Without any visible change, the albumen undergoes a chemical transformation, the solution losing the property of being coagulable by heat and nitric acid. Coagulated albumen, before being dissolved, becomes pellucid and softened. With a square fragment of hard-boiled white of egg, for instance, submitted to artificial digestion, it is observed that the angles and edges first of all lose their opacity. The albumen at the surface becomes converted into a transparent, soft, jelly-like substance, which is afterwards removed by solution. This action being continued, the whole fragment ultimately disappears.

Caseine is in the first instance precipitated, but afterwards re-dissolved. It is for this reason that milk is invariably curdled in a very short time after being received into the stomach. When re-solution has taken place, the caseine is found to have disappeared,

the liquid being no longer precipitable by the addition of an acid.

Gelatine in the solid state is dissolved and transformed. In solution there is no physical change to be seen, but the property of gelatinizing on cooling is destroyed.

Although the special province of the stomach may be said to be the digestion of the nitrogenized group of alimentary principles, yet the non-nitrogenized group do not probably wholly escape undergoing some amount of change in the organ.

With the saccharine element, which belongs to this group, no digestion whatever is required to be performed. Being of a soluble and diffusible nature, the saccharine principle is ready, without requiring to pass through any process of preparation, for absorption.

Starch must be acted upon and transformed before it can be absorbed. The stomach is certainly not the organ functionally designed for effecting this transformation. Nevertheless, as suggested by Dr. Bence Jones, the acid of the gastric juice may occasion some transformation of starch into sugar.

Fatty matters are emulsified or rendered fit for absorption in the small intestine. According to Dr. Marcet, however, the neutral fats are acidified in the stomach, and thereby placed in a fit condition for being acted upon by the bile, which has the power of emulsifying the acid, but not the neutral fats. When the fat of meat is eaten, the membranous element belonging to it is dissolved by the gastric juice, and the fat, liquefied by the heat of the body, escapes and diffuses itself in a free state amongst the contents of the stomach.

The presence of oily matter intimately incorporated with or diffused through a substance renders it difficult of penetration by the gastric juice—and thereby, of digestion in the stomach. Almonds and nuts, and such-like oily articles, owe their well-known indigestibility to this cause. Unless they have been very finely pulverised or comminuted (by which their indigestible character is removed) before being received into the stomach, obstruction, as may be readily understood, is offered to their penetration by the watery secretion that is to dissolve them, and so their difficult digestibility is accounted for.

Taking the various articles of food that are consumed, ordinary experience suffices to teach us that they yield with varying degrees of facility to the process of digestion. Dr. Beaumont, however, conducted an elaborate series of observations upon this matter, and framed a table from which the following extract has been taken. Through the position in which Dr. Beaumont was placed, he was afforded the opportunity of noting exactly at what period the digestion of an article was completed; but it must be borne in mind that his observations were all conducted upon one individual; and it is possible, if a more extended field of observation had presented itself to him—if he had been enabled to conduct his observations upon several individuals instead of only one, some modifications would have occurred in the table that he has produced: at all events, there are points in which the table given certainly does not conform with the notions derivable from general experience.

Extract from Dr. Beaumont's Table, showing the mean time in which various articles of food underwent digestion in the stomach of Alexis St. Martin.

	Hrs.	Mins.
Rice, boiled	1	00
Milk, boiled	2	00
Do., unboiled	2	15
Pig's feet, boiled	1	00
Tripe, boiled	1	00
Venison steak, broiled	1	35
Turkey, roasted	2	30
Do., boiled	2	25
Goose, wild, roasted	2	30
Pig, sucking, roasted	2	30
Liver, broiled	2	00
Lamb, broiled	2	30
Chicken, fricasseed	2	45
Eggs, hard-boiled	3	30
Do., soft-boiled	3	00
Do., fried	3	30
Do., raw	2	00
Custard, baked	2	45
Cod-fish, cured and dry, boiled	2	00
Salmon trout, fresh, boiled	1	30
Salmon, salted, boiled	4	00
Oysters, raw	2	55
Do., roasted	3	15
Do., stewed	3	30
Beef, fresh and lean, roasted	3	00
Beefsteak, broiled	3	00
Beef, hard, salted, boiled	4	15

	Hrs.	Mins.
Pork, fat and lean, roasted	5	15
Do., recently salted, boiled	4	30
Mutton, roasted	3	15
Do., boiled	3	00
Veal, broiled	4	00
Do., fried	4	30
Fowl, boiled	4	00
Do., roasted	4	00
Duck, roasted	4	00
Do., wild, roasted	4	30
Beef suet, boiled	5	30
Mutton suet, boiled	4	30
Cheese, old strong	3	30
Soup from beef, with vegetables and bread	4	00
Do., barley	1	30
Do., mutton	3	30
Do., oyster	3	30
Hash (meat and vegetables)	2	30
Sausage, broiled	3	20
Heart, fried	4	00
Bread, wheaten and fresh	3	30
Sponge-cake	2	30
Apple-dumpling	3	00
Apples, sour and hard	2	50
Do., sour and mellow	2	00
Do., sweet and mellow	1	30
Parsnips, boiled	2	30
Carrots, boiled	3	15
Turnips, boiled	3	30
Potatoes, boiled	3	30
Do., baked	2	30
Cabbage, boiled	4	30

Seeing that the stomach acts upon and dissolves substances identical with itself, it becomes a question of paramount interest to us to know how it is that it escapes being itself digested whilst digestion is proceeding in its interior. The position occupied by the stomach amounts in reality to this :—a vessel composed, say, of marble is used as a receptacle in which the process of dissolving fragments of marble is carried on by means of an acid: the fragments are found to disappear, whilst the vessel itself remains intact. The question proposed is one that concerns us at every meal we consume; for did the stomach yield to the solvent influence of its secretion, like its contents, solution resulting in perforation could not fail to take place, and must inevitably lead to the destruction of life.

John Hunter was the first to direct attention to this point. In a communication published in the 'Philosophical Transactions' for 1772, entitled "On the Digestion of the Stomach after Death," Hunter remarks that in occasional instances, especially in persons who have died of sudden and violent deaths, on making an inspection of the body, the great extremity of the stomach is found so dissolved as to have allowed of the escape of its contents into the abdominal cavity. He further states that although a perforation of the stomach may not be observed, yet there are very few dead bodies in which the stomach is not at its greater end in some degree digested, this partial digestion being indicated by a thinness and transparency of the membranes, and by the blood which the vessels contain passing out at their digested ends when pressure is

made from the larger towards the smaller branches, and appearing like drops on the inner surface.

The greatest extent of solution having been observed by Hunter in cases where the individual had been in the enjoyment of perfect health up to the moment of death, he inferred that the phenomenon could not have arisen from disease during life, but must have been owing to an action exerted by the digestive fluid after the occurrence of death.

The stomach being thus presumed to be susceptible of yielding to the digestive influence of its own secretion after death, it became necessary to account for its not yielding in a similar manner during life. According to Hunter, it was the "living principle" that afforded the required protection to the living organ. "The stomach," he said, "which at one instant—that is, while possessed of the living principle—was capable of resisting the digestive powers which it contained, the next moment—namely, when deprived of the living principle—is itself capable of being digested, either by the digestive powers of other stomachs, or by the remains of that power which it had of digesting other things." He further, in illustration, continues: "If it were possible for a man's hand to be introduced into the stomach of a living animal, and kept there for some considerable time, it would be found that the dissolvent powers of the stomach could have no effect upon it; but if the same hand were separated from the body and introduced into the same stomach, we should then find that the stomach would immediately act upon it."

No question can be raised about the fact that the stomach is often found in a more or less digested state after death. *Post-mortem* examinations supply

frequently recurring examples of the gastric solution that Hunter has described. By artificial means, however, the phenomenon may at any time be made manifest, and to an extent far more striking than that corresponding with the description that Hunter has given. A rabbit, for instance, being killed whilst the process of digestion is going on, and the warmth of its body being afterwards artificially maintained, an opportunity is given for the occurrence of digestive action after death, and so a truly astonishing result may be occasioned. With a rabbit killed in the evening, and its body exposed during the night to a temperature of about 100° Fahr., I have before now found that, besides the stomach being dissolved away, its contents, escaping into the abdominal cavity, have produced the most extensive ravages upon the surrounding parts, the effects reaching as far as the skin upon the side on which the animal has been laid, and to which the gastric juice would gravitate.

There can be no question, then, that the secretion of the stomach acts upon and dissolves the organ itself after death, like any other substance subjected to its influence. The reason that more extensive evidence of its action upon the stomach, than a softening of the mucous membrane, is not ordinarily found in *post-mortem* examinations, is because it often happens that there is no gastric juice in the interior of the organ at the time of death, and because the fall of temperature which the body undergoes after death exercises so great an influence in diminishing the energy of digestive action. Owing to the latter circumstance, the greatest extent of solution is most likely to be encountered

during the hot weather of summer, when the fall of temperature after death takes place with the least rapidity.

Upon one occasion I procured and experimented upon a stomach filled with contents which had been removed from a pig that had been killed a few hours after having been fed. Whilst exposed to the ordinary temperature of the atmosphere, it remained intact, as far as from external appearances could be seen. It was now placed in a situation where it was exposed to a temperature of about 100°; and in the course of a short time it was found that the contents had acted upon it so as to have caused an extensive perforation, through which they had made their escape.

Hunter's theory, it has been found, fails to stand when subjected to the test of experiment. An ingenious experiment, performed by Bernard, of Paris, has shown that the "living principle" does not afford protection, as alleged by Hunter, from the solvent influence of the digesting stomach. Through an artificial opening into the stomach of a dog, Bernard introduced the hind legs of a living frog, whilst the process of digestion was being carried on. The legs, he found, were digested and dissolved away, notwithstanding that the frog itself continued alive. I have repeated the experiment, and obtained a confirmatory result.

The above experiment unquestionably proves, in opposition to Hunter's view, that the stomach has the power of dissolving living substances, and, therefore, that the "living principle" does not afford the protective influence that was alleged. As an argument, however, against the "living principle" constituting the source of protection to the stomach from self-digestion

during life, it appeared to me that it could scarcely be looked upon as conclusive; for it might be urged that the vitality of the tissues of the frog—a cold-blooded reptilian animal—might suffice to enable them to resist the digestive influence of its own stomach, and yet be insufficient to afford the required amount of resistance to the more powerfully acting stomach of a warm-blooded animal like the dog. I therefore performed an experiment in which tissues belonging to a warm-blooded animal were submitted to the digestive action of the dog's stomach. The ear of a rabbit was substituted for the hind legs of a frog, and with what result the following account of the experiment will disclose:—

Whilst a dog in which a gastric fistula had been established was at a period of full digestion, the tip of one of the ears of a vigorous rabbit was introduced through the canula into the stomach, and held there with the hands, in order to avoid inflicting any mechanical injury, or obstructing its circulation by compression of its blood-vessels. At the end of two hours the ear was withdrawn, and some spots of erosion—one as large as a sixpenny-piece—were observed on its surface; but nowhere was it eaten completely through. On being replaced for another two hours and a half, the tip, to the extent of rather more than half an inch, was almost completely removed, a small fragment only being left attached by a narrow shred to the remainder of the ear. The gastric juice seemed to act like a strongly corrosive agent, making first some ulcer-like spots upon the surface, and afterwards extending its action to the central parts. A considerable escape of blood took place, especially towards the latter part of

the experiment. My own fingers, becoming moistened with the gastric juice that escaped from the stomach by the side of the ear, felt somewhat sore or tender from the skin having been to a slight extent acted upon.

The "living principle" being refuted, it was suggested by Bernard that the stomach owes its escape from self-digestion and perforation during life to the power it possesses of renewing its epithelial layer. The stomach, he said, is lined with a layer of epithelium and mucus, which acts as a kind of varnish in affording protection to the deeper parts. Whilst digestion is going on, the epithelium and mucus are constantly being dissolved and removed, like the food contained in the stomach; but a fresh supply being as constantly reproduced, the organ is maintained intact. When death has taken place, the power of renewing the epithelial lining that has been removed no longer existing, the gastric juice would arrive in contact with the deeper parts, and, circumstances being favorable to the continuance of digestive action, would successively exert its solvent influence upon them, until the phenomenon of perforation resulted.

An exaggerated notion has been formed of the thickness of the layer of epithelium and mucus belonging to the stomach, through the rapid attack made on the mucous membrane by the digestive fluid after death. When the stomach of a rabbit is removed and opened immediately after death, the mucous membrane is firm, and lifts off cleanly from the mass of food beneath, without giving any appearance of the existence of an intervening layer of mucus. If a short time only, however, should be allowed to elapse before the stomach is examined after death, a more or less thick, pulpy,

white layer will be found adhering to the surface of the mass of food, which looks like a layer of mucus, but consists, in reality, of digested mucous membrane, and constitutes, therefore, a *post-mortem* production.

Experiment shows that the explanation which refers the escape of the stomach from destruction by its own secretion during life to a protective influence exerted by its epithelial layer, will no more stand investigation than the "living principle." I have found ("On the Immunity enjoyed by the Stomach from being digested by its own Secretion during Life," 'Transactions of the Royal Society,' 1863) that the excision of a patch of mucous membrane from the stomach of a living animal is not followed by digestion of the subjacent parts, and thence perforation—phenomena that would be looked for if the protection were owing to the epithelial layer. Digestion goes on in such a stomach without the structures opposite the denuded part exhibiting any evidence of attack. The walls here evince no signs whatever of enjoying less security than elsewhere; and on the animal being allowed to live, I have found that repair by cicatrization has ultimately completely taken place.

Independently of the evidence afforded by experiment, it may be assumed, upon reflection, that something more constant—some condition presenting less exposure to the chance of being influenced by external circumstances — than that resting upon the existence of an epithelial covering is required to account for the remarkable security from destruction by its own secretion which the stomach is found to enjoy during life. From the position the stomach occupies as a receptacle for everything that may chance to get

swallowed, it can hardly escape having its mucous membrane occasionally abraded: and yet its integrity is found to be maintained. Ulceration of the stomach, also, is not of uncommon occurrence; but it does not necessarily lead to perforation as a result. Perforation, it is true, does sometimes occur as a consequence of ulceration; but the same event is noticeable in the case of other parts of the alimentary tract, and there is no reason to regard it in the stomach, more than elsewhere, as due to anything besides the ordinary progress of the ulcerative process.

The question, it must be considered, then, as to how it happens that the stomach, composed as it is of digestible materials, escapes during life being digested itself whilst digestion is being carried on in its interior, still remains, as far as the explanations already referred to are concerned, an open one for solution. It is evident, upon consideration, that whatever explanation claiming any pretensions to sufficiency is given must comprise some broad principle of action capable of providing against all contingencies—capable of affording, in fact, that uninterrupted security during life which, upon looking around us, we observe the stomach to enjoy.

The view that I have offered ('Philos. Trans.,' 1863) is founded upon the permeation of the walls of the stomach by an alkaline current of blood; and this agrees with the principle I have laid down as indispensable, for the circulation of blood forms with us one of the essential conditions of life. It will not be disputed that the existence of acidity constitutes a necessary condition for the accomplishment of gastric digestion. Alkalinity is also a constant character of the

blood. Now, the walls of the stomach being everywhere permeated by a current of alkaline blood, an opposing influence is raised to the occurrence of digestion. The gastric juice, it may be considered, is constantly tending to penetrate and act upon the stomach, as well as upon the food contained in its cavity; but attack upon the stomach is prevented by the destruction of solvent power that is induced by the neutralizing influence exerted by the current of alkaline blood which happens to be always flowing through the gastric walls during life.

This view will be found to be perfectly reconcilable with the yielding of the stomach to the digestive influence of its secretion that is noticed to occur after death. As death takes place, the circulation is stopped, and the protecting influence is lost that it afforded during life. There is only the blood that is stagnant in the vessels to exert a neutralizing effect; and should death happen to take place at a period of digestion, the neutralizing capacity of this will be altogether inadequate to prevent the gastric juice that is present attacking the stomach as well as its contents. Digestion of both stomach and its contents proceeds as long as the temperature is kept up to a suitable degree for the purpose, and the solvent power of the gastric juice remains unexhausted.

In the special arrangement of the vascular distribution that is found to exist in the mucous membrane of the stomach, security, according to the view I have propounded, seems to have been rendered, as it were, doubly secure by the doubly effective barrier that may be said to have been provided against the progress of digestion. At the suface of the stomach there exists a

closely woven plexus of capacious capillaries, which, as has been previously pointed out, derive their blood, not from arteries, but from the capillaries which course upwards between the gastric tubules. Now, it is from the blood circulating in the capillaries between the tubules that the acid constituent of the gastric juice is drawn; and it follows, therefore, that in proportion as acid is separated here, the blood circulating in the capillaries at the surface must be correspondingly increased in alkalinity. Thus, it will be remarked, not only is the alkalinity of the blood greatest just where alkalinity is most wanted for its protecting influence—viz., at the surface—but in proportion as acid flows into the stomach and creates a demand for a protecting influence, so is the blood circulating at the surface rendered more alkaline, and thereby more efficacious as a protecting medium. Looking at nature's arrangement, the act creating a demand for the exercise of neutralizing action enhances the character of the neutralizing capacity provided.

There is another point that is well deserving our consideration. I think it may be put down that the acid and the organic constituent of the gastric juice, the admixture of which is required to produce a solvent menstruum, are not secreted together, and only meet each other at the surface of the stomach. The organic constituent, it is known, is always present in the mucous layer at the surface, and is probably secreted by the superficial epithelial cells belonging to the organ. The fluid part of the gastric juice, on the other hand, containing its acid principle, is only secreted intermittingly; and from its exuding from the surface, as it does, in little drops, when its flow is

excited by the stimulus of food or other extraneous matter, it may be considered, without much doubt, as coming from the glandular tubules in the substance of the mucous membrane. Now, if this constitutes the manner in which the gastric juice is formed—if the gastric tubules, which are lined with quite a different kind of epithelial cell to that belonging to the surface, secrete only an acid fluid—a solvent menstruum is not formed until this fluid reaches the surface, and becomes incorporated with the organic principle that, as already mentioned, is constantly present there. Thus, the presence of a liquid endowed with solvent properties, like those possessed by the admixture of acid and pepsine, is avoided in the delicate secreting tubules that extend into the substance of the mucous membrane, and it is left to the current of blood at the surface, which happens to be the most efficient for the purpose on account of its alkalinity being harmoniously increased in correspondence with the amount of acid poured out into the stomach, to form the barrier of resistance to the digestive influence.

In support of my view, I have found by experiment (*vide* 'Philos. Trans.') that by stopping the circulation through a portion or the whole of the stomach, digestive solution, wherever the circulation is arrested, is thereby allowed to proceed as in its ordinary course upon food. As the result of ligaturing the vessels of the stomach in a rabbit, I have witnessed digestion of its walls proceed during life to the extent of perforation. On pinching up and placing a ligature also around a portion of the walls of the stomach so as to cause a constricted mass to project into the gastric cavity, this ligatured mass, in which the

circulation has been arrested, has been found to yield to digestion, to the exclusion of the other parts of the stomach, as though it consisted of a morsel of food.

It will naturally be required of me to reconcile the view I have advanced with the action that has been described as having occurred on the living frog's legs and rabbit's ear when introduced through a fistulous opening into a dog's stomach; and submitted to its digestive influence. If the circulation, through its neutralizing capacity, affords protection to the stomach, why, it may be asked, does it not afford equal protection to the tissues of living animals that may be introduced into its cavity? I thus put the question plainly, because it is one that requires to be, and is susceptible of being, plainly answered.

According to the proposition offered, the stomach is protected because the neutralizing power of its circulation is sufficient to overcome the acidity of the gastric juice which is tending to penetrate and attack it. This proposition, it will be seen, involves the result in a question of degree of power between two opposing influences. Suppose the neutralizing power of the circulation to be diminished below a certain point, whilst the strength of the digestive liquid is allowed to remain the same; theoretically the result should be in favour of digestion instead of protection, and practically this may be regarded as having been the position in the experiments with the frog's legs and the rabbit's ear. Suppose, on the other hand, the neutralizing capacity of the circulation of the stomach to be allowed to remain in its natural state, whilst the strength of the acidity of the digestive liquid is increased so as to become the superior of the two; theoretically digestion

of the stomach should take place, and practically, as will be presently seen, this is precisely what occurs.

With regard to the frog's legs and rabbit's ear experiments, the following is the explanation that I have to offer:—In the case of the frog's legs, it may be fairly taken that in the amount of blood possessed by the animal we have a neutralizing capacity which is totally inadequate to oppose the strength of acidity belonging to the dog's gastric juice; and so, to furnish the required means of resistance to its digestive influence. In the case of the rabbit's ear, its degree of vascularity is so very different—so much less, as compared with that of the dog's stomach, that there is nothing irreconcilable in the one yielding to and the other resisting attack. The widest diversity, for instance, exists in the position of the stomach and that of the ear. The stomach is not only in itself an exceedingly vascular organ, but is completely surrounded by equally vascular parts. The ear forms a structure that projects in an isolated manner from the surface; is only supplied with blood from its base; in texture is of an infinitely less vascular nature than the stomach; and situated as it was in the experiment, it must have been completely surrounded by or bathed in gastric juice.

Now, two opposing forces are considered to be in operation, and the result to be dependent upon which is the stronger of the two. Because with its high degree of vascularity the stomach is enabled to exert a sufficient amount of neutralizing influence on the acidity of the gastric juice to stay the progress of digestion upon itself, it does not follow that other parts, endowed with a lower degree of vascularity, should be able to do the same. Even with the stomach itself the circulation

may be rendered, as will now be shown, incapable of affording the required neutralizing power, by increasing beyond a certain point the strength of acidity of its contents.

It has been already mentioned that, on arresting the circulation of the stomach whilst digestion is going on, the stomach yields as well as its contents. This yielding I have observed in the case of the rabbit to proceed to the extent of perforation; but in the dog it has only amounted to softening and solution of the mucous or internal coat—a circumstance that evidently depends upon the contents of the stomach being less powerfully acid in the dog than they are in the rabbit; for, on increasing their acidity before the circulation is stopped, digestion more actively proceeds, and soon gives rise to the occurrence of perforation. It is possible that some acid may be generated from the food in the stomach of the rabbit, as well as derived from the process of secretion; at all events, the strength of acidity of the contents of the stomach is conspicuously great in this animal.

It has just been stated that if an acid be introduced into the stomach of the dog, and the circulation through its walls be stopped, digestion afterwards actively proceeds, and soon occasions perforation. A moderate amount of acid suffices for producing this result; and the dilute phosphoric and the citric are the acids I have employed in my experiments, that no corrosive action should be exerted. In other experiments, where the same acids, in the same quantities, have been introduced into the stomach, and its circulation allowed to remain free, no digestion of its parietes has occurred. On proceeding further, however, but still without intro-

ducing a liquid that would act corrosively on the tissues, the stomach yields to solution, notwithstanding its circulation is left free. In an experiment where dilute hydrochloric acid was employed, perforation took place in an hour and forty minutes, and the stomach throughout was in an advanced state of digestion. A considerable amount of blood, it was found, had escaped from its vessels; and it will be remembered that considerable hæmorrhage was also remarked from the rabbit's ear as it was undergoing digestion in the dog's stomach.

Thus, in one set of experiments, where a certain quantity of acid is introduced into the stomach, and the circulation of blood through its walls arrested, it is found to yield to digestion, because there is no neutralizing agency in operation to destroy the acidity—and thereby the activity—of the gastric juice tending to penetrate and act upon its texture.

In another set of experiments, of precisely the same kind, except that the circulation is allowed to remain free, the stomach escapes, because the penetration of its walls by gastric juice in an acid and active state is prevented.

In a third kind of experiment the circulation is again left free; but the quantity of acid is increased, and the stomach yields, because, as in the case of the rabbit's ear and frog's legs, the neutralizing capacity of the circulation is insufficient to overcome the acidity that is opposed to it. I look upon these results as in the highest degree confirmatory of the view that has been propounded.

One point yet remains to be referred to before I dismiss the subject under consideration. It is incom-

patible with the view proposed that a living organism should be capable of existing *in a free or isolated state* in an actively digesting stomach, without yielding to attack, unless it should consist of, or be invested and protected by, an indigestible material. Now, it is well known as a veterinary fact, that larvæ of the *Œustrus* (bots) are sometimes met with in large numbers in the stomach of the horse; and it might appear, at first sight, that we have here an instance standing at variance with the proposition that has been laid down. It will be found, however, if attention be given to the point, that these larvæ do not live in an unattached state in the stomach. They exist with their mouths firmly attached to and buried in the inner coat; indeed, the inner surface of the stomach is often to be seen hollowed into a number of cells of a honeycomb nature, into which the larvæ, from the telescope-like construction of their bodies, can draw themselves so as almost to be concealed. Living upon the juices of the animal they infest, they also become more or less, as it were, a part and parcel of the stomach's parietes; and it is further to be remarked that the principle, chitine, which forms the basis of the external tunic of members of the insect tribe, is of an exceedingly indigestible nature. The indigestible character of the investment of these larvæ is shown by the fact that, after they become detached, they pass through the stomach and along the alimentary tract, without suffering loss of life, for they are found to be voided in a living state.

Professor Simonds has informed me that he has met with an entozoon (a species of *Filaria*) which inhabits the last stomach of the sheep. This parasite, however, like the *Œustrus*, lives firmly attached to the mucous

membrane; and I have not been able to learn that any example can be brought forward of an isolated digestible organism living in the healthily acting stomach without yielding to digestion. The older physiologists discovered, during their early experiments on digestion, that leeches and earthworms inserted into perforated metal spheres, and introduced in a living state into the digesting stomach, underwent digestion like morsels of ordinary food.

I will now proceed to speak of the morbid phenomena connected with the action of the stomach.

VOMITING.

Vomiting constitutes a form of morbid action consisting of the rejection of the contents of the stomach by means of violent involuntary muscular efforts. The occurrence of the muscular efforts without any ejection taking place from the stomach constitutes what is known as retching. Although the act of vomiting cannot be regarded as forming one of the ordinary or natural events of life, yet, when excited by the presence of irritant or noxious matter in the stomach, it must be looked upon as constituting a most salutary process, leading, as it does, to the rejection of ingesta, which, if retained, would prove hurtful to the system. It may be compared in its object to the acts of sneezing and coughing—muscular phenomena effecting the expulsion of irritating matter from the respiratory passages.

The act of vomiting is usually ushered in by a peculiar sense of uneasiness—a feeling of nausea, as it is termed. This is usually accompanied with more or less giddiness or faintness, coldness of the surface, pallor of the lips and face, dejection of countenance, and smallness, feebleness, and irregularity of pulse. As the act is about to be accomplished, the chest is filled with air by a long-drawn and often sonorous inspiration. The glottis being now closed, the violent muscular efforts that ensue exert a powerful compressing action upon

the stomach. The cardiac orifice of the organ is at this time relaxed to permit of the escape of its contents, which, by the retrograde action of the œsophagus and pharynx that follow, are raised into the mouth, and thence ejected from the economy. The temperature of the surface now rises, and the pulse becomes frequent and full; but if the vomiting has been severe, a state of general prostration is induced.

To prevent the vomited matters passing through the nose as well as the mouth, the posterior pillars of the fauces are drawn together so as to shut off the upper from the lower part of the pharynx, precisely as occurs during the process of deglutition. It not unfrequently happens, however, from the suddenness and violence of the expulsive efforts that occur, that some of the vomited matters are driven towards and expelled through the nose—a circumstance that adds considerably to the state of discomfort already existing.

With prolonged vomiting or retching, a backward flow of bile takes place, probably from an inverted action of the duodenum, into the stomach; and this accounts for the appearance of bile in the vomited matters that is observed to occur. The colour of the bile ejected varies according to circumstances. At the commencement of vomiting it is yellow—at a later period it is green. This is seen in cases of sea-sickness, as well as in sickness dependent on other causes. As long as any acid remains in the stomach the bile, in passing through, is rendered yellow. As soon, however, as vomiting has been sufficiently prolonged for all trace of acid to be expelled, the bile discharged is green instead of yellow. The compression to which

the liver and gall-bladder are subjected will account for the quantity of bile that may be discharged.

Much difference of opinion has prevailed regarding the agency by which the contents of the stomach are expelled, or as to the part played by the stomach and abdominal muscles during the act of vomiting. Magendie instituted and performed a series of experiments on the subject, and, from the results he obtained, maintained that the stomach was perfectly passive during the process, the act of expulsion being wholly effected by the conjoint contraction of the diaphragm and abdominal muscles.

Observation, it is true, has shown that attempts at vomiting are ineffectual when the stomach is left, as when extruding from the abdominal cavity, to its unaided efforts to expel its contents. This, however, can by no means be taken as proving that its condition is a passive one during the ordinary performance of the act. A case has been recorded* in which a man was gored by a bull, and left with his stomach projecting from the abdominal cavity. Whilst the stomach was protruding, the efforts at vomiting, and these were very violent, produced no effect; and no appearance was to be seen of any contractile action of the organ itself taking place. Immediately, however, that the stomach was returned into the abdominal cavity the same efforts that were before ineffectual in expelling anything from its cavity brought about an ejection of its contents. Such I find, on reference to the original source, to be the facts of this case, which, as far as it goes, tells against the stomach exerting any contractile action. Strangely enough, as the case is quoted by

* Lepine, 'Bulletin de l'Académie de Médecine, 1843-4.

authorities in general in this country, it is represented as proving exactly the reverse of what it really does, it being made to appear that, whilst protruding, the stomach was to be seen forcibly contracting, and that by its unaided efforts it effected an expulsion of its contents.

The phenomena observed in the above case, as mentioned by Lepine, exactly correspond with the description given by Magendie of the result obtained when an animal was experimentally placed in a similar position. Referring to my own experience, upon one occasion, whilst conducting an experiment upon an animal under the influence of chloroform, the stomach was incidentally forced out, during some efforts at vomiting that occurred, through an opening that had been made in the abdominal parietes. The stomach at the time was distended with food; and I noticed that as long as it protruded from the abdominal cavity the efforts at vomiting were ineffectual in causing any expulsion of its contents; whilst directly it was returned the efforts were accompanied with an ejection of food.

Evidence of this kind certainly shows that, without the agency of the compressing action exerted by the abdominal parietes, vomiting fails to be effectively performed; but it does not show that the stomach is a passive organ in the act. It would be unreasonable to look for the production of any sharp or immediate effect by the contraction of the stomach, such as occurs in the case of the abdominal muscles, because its muscular fibres are of a kind that do not act in this manner. They only undergo a slow process of contraction in respondence to a stimulus; and in the absence of direct proof to the contrary, it is fair to assume that, like the analogous fibres belonging to the

rectum and bladder, which unquestionably aid in the performance of defæcation and micturition, they help in expelling the contents of the stomach during the act of vomiting. The contraction of the stomach upon its contents would tend to open the cardiac orifice; and this, it is evident, must form one of the train of phenomena belonging to vomiting, because the mere compression of the stomach by the abdominal parietes, as during violent straining for example, does not produce an expulsion of its contents.

Dr. Marshall Hall contended that the diaphragm takes no share in the production of the expulsive efforts that accompany vomiting. He considered it to be only muscles of expiration that were thrown into contraction, and compared the act to a forcible expiratory effort allied to that of coughing, in which, indeed, he remarked the contents of the stomach are frequently expelled. Now, the diaphragm and the other muscles belonging to the walls of the abdomen —the group of abdominal muscles, as they are called— certainly antagonise each other in their effect upon the cavity of the chest, and therefore are not in simultaneous action in the process of respiration; but, as regards the cavity of the abdomen, the circumstances are different, and harmony is consistent with their simultaneous contraction. In the act of coughing it is necessary that the diaphragm should be relaxed, to enable the abdominal muscles to produce the sudden expulsion of air from the chest through the open glottis that occurs. In the act of vomiting, however, where the effect required is the compression of the stomach, if the diaphragm formed a relaxed or floating partition between the chest and abdomen, as suggested by

Marshall Hall, the action of the abdominal muscles would be thrown as much upon the thoracic as upon the abdominal cavity; and with the glottis closed, as is the case, the lungs would be subjected to the full force of the muscular contraction taking place. The expulsive effort of vomiting is always preceded by a deep inspiration, and the diaphragm remaining contracted would both assist in compressing the stomach and in relieving the lungs, the compression of which is not wanted. It is now, indeed, to be stated, as the result of the experimental inquiry of Dr. Anderson,* that the diaphragm has been actually found to be in a forcible state of contraction during the act of vomiting.

By an anti-peristaltic movement in the œsophagus, the vomited matters are raised from the stomach up into the mouth. This reversed peristaltic action has been witnessed in the œsophagus after the injection of tartar emetic into the veins, even after its separation from the stomach has been effected. It occurs in eructation and rumination, and is here unaccompanied with the retching efforts that are observed in vomiting. It effects a return of the food and drink in cases of dysphagia; and in simple retching it occurs without being attended with the passage of anything along the tube. We seem to be conscious of its being about to take place, and have the power by swallowing of restraining its occurrence for a little while.

Some persons have possessed the faculty of ejecting the contents of their stomach at will, and two cases of the kind—those of Gosse and Montegre—are on record in which it was turned to account for investigating the phenomena of digestion. Gosse,

* 'Lond. and Ed. Monthly Journal,' 184.

of Geneva, ejected the contents of his stomach by a true process of vomiting; and it was by swallowing a quantity of air that he excited the performance of the act. His observations on the digestibility of different articles of food are given in Sennebier's French translation of 'Spallanzani on Digestion.' In Montegre's* case the ejection from the stomach was effected by a process akin to eructation. Without any apparent effort, or any of the muscular phenomena that are seen in vomiting, he could at any time throw up matters from the stomach into the mouth, just as is done by the ruminant animal. Montegre conducted an extensive series of observations upon himself, but was led into error concerning the nature of the digestive fluid. The fluid raised by him at a period of fasting, which presented the characters of mucus and saliva, was mistaken for the pure gastric juice, the strong acidity of the contents of the stomach during digestion being attributed, not to secreting action, but to the generation of an acid from the food.

According to accounts given us, the act of vomiting used to be sometimes purposely excited by the ancients to enable them to prolong the enjoyments of the table. The Romans, it is said, sometimes excited vomiting to eject from the stomach what they had eaten in one course, that they might be the more capable of enjoying what was to follow. As Seneca has it, "they vomited that they might eat, and ate that they might vomit." They employed emetics before meals that they might be able to eat the more plentifully, and often concluded a feast with an emetic to prevent the consequences of gluttony.

* Montegre, 'Experiences sur la Digestion.' Paris, 181[illegible]

Vomiting is a reflex nervous act, and may be excited, not only by causes acting on the stomach, but also by causes acting on a variety of other parts.

The most natural cause—if it may be so termed—of vomiting is a source of irritation acting upon the stomach itself. Vomiting thus produced may be due to the introduction of irritant bodies into the stomach; to the presence of articles of food that prove refractory to or difficult of digestion—these by their prolonged sojourn becoming a source of irritation to the healthy stomach; or, lastly, to the presence of ordinary articles of food in a morbidly irritable or sensitive stomach. Vomiting excited by an impression starting from the stomach may further have its source of origin in some morbid condition of the organ without the co-operation of any foreign influence.

The vomiting that occurs during the passage of biliary and renal calculi, during pregnancy, in peritonitis, and from hernia or strangulation of the intestine, form examples of vomiting provoked by a peripheral irritation not starting from the stomach. The impression derived from mechanical irritation or titillation of the fauces is well known to have the power of exciting vomiting. The first effect that is here produced consists of anti-peristaltic contractions of the pharynx and œsophagus. These are more or less speedily followed by a concerted action of the stomach and abdominal muscles, which results in vomiting. As an illustration of the difference in the reflex phenomena that may be produced by the stimulation of parts situated in close proximity to each other, it is found that irritation, applied a little beyond the fauces, excites peristaltic movements and the performance of swallowing, instead

of anti-peristaltic movements and the performance of vomiting. Instances, for example, are mentioned by Marshall Hall of patients who, in attempting to excite vomiting by tickling the fauces with a feather, caused, instead, the feather to be swallowed by applying the irritation too far down. The vomiting so frequently observed as a concomitant of a violent paroxysm of coughing is probably in great part, if not wholly, due to reflex action arising from the source of irritation existing at the pulmonary extremities of the pneumogastric nerves. The influence of the physical compression to which the stomach is subjected by the powerful contractions of the abdominal muscles, that take place during vomiting, may possibly have something to do with it; but the main cause is probably the irritation of the pneumogastrics referred to.

Certain impressions acting upon the special organs of sense—as, for instance, a repulsive sight or a disgusting smell or taste—are capable of exciting the performance of vomiting. Even the thoughts of such sensations, and, therefore, an impression starting from the brain, and originating in a mental operation, may suffice, in a susceptible disposition, to afford the requisite stimulus for exciting the accomplishment of the phenomenon. The influence upon the sensorium produced by the motion of the body is probably the cause of the vomiting of sea-sickness. The same also applies to the vomiting that in some persons may be induced by swinging; by a rotatory movement of the body, as in waltzing, &c.; and by the motion derived from riding in a carriage, particularly with the back directed towards the horses. In support of its being through an influence upon the sensorium, that the effect is produced under these cir-

cumstances, it is well known that the sight of an object in certain kinds of motion may induce a feeling of giddiness and sickness.

Irritation of the nervous centre, as the result of disease, forms a not unfrequent source of vomiting. It is with morbid conditions of the brain, however, and not of the spinal cord, that vomiting is thus associated. It constitutes, indeed, one of the symptoms looked for in cases of injury to or disease of the brain, and especially when the base of the organ forms the seat of affection. The spinal cord rarely bears any etiological relation to vomiting.

The brain and stomach sympathise in a very intimate manner with each other. Not only does vomiting form so frequent a concomitant, as has been mentioned, of cerebral disease, but the occurrence of headache in association with stomach derangement is also a matter of daily observation. Where a doubt exists as to the cause of the vomiting, the following, according to Romberg's experience,* are the characteristic symptoms which indicate that it arises from a cerebral influence: —"1. The influence of the position of the head: the vomiting is arrested in the horizontal, and recurs and is frequently repeated in the erect position. It is also easily induced by movements of the head, by swinging, shaking or stooping, or sudden rising. 2. The prevailing absence of premonitory nausea. 3. The peculiar character of the act of vomiting: the contents of the stomach are ejected without fatigue or retching, as the milk is rejected by babies at the breast. 4. The complication with other phenomena, the more frequent of

* Romberg on "Diseases of the Nervous System," vol. ii. p. 19. 'Sydenham Soc. Translation.'

which are pain in the head, constipation, and the irregularity of the cardiac and radial pulse, which is increased during and subsequent to the act of vomiting. The duration of the vomiting is limited in the inflammatory affections of the brain, meningitis, encephalitis, and acute hydrocephalus, to the first stages of the disease; and the prevailing rule is, that, as the paralytic and comatose symptoms increase, the vomiting remits and ceases."

Poisonous agents—as tartarized antimony, arsenic, &c.—induce vomiting when introduced into the circulatory system, as well as into the stomach. They probably exert a special influence upon the nervous system that determines vomiting; but the effect may be in part due to a topical action of the agent upon the mucous lining of the stomach; for the stomach is found to exercise an eliminative action upon it. Thus, in some experiments where I had injected the poison into the veins of dogs, it was afterwards chemically recognised amongst the contents of the stomach and intestine by Dr. Alfred Taylor; and some mice were killed by eating the vomited matters from a dog so experimented upon. The vomiting which may attend the invasion of an acute febrile, exanthematous, or pestilential malady, is probably dependent upon the action of a morbid or poisoned condition of the blood upon the nervous system.

In the treatment of vomiting the practitioner has to be guided by the nature of the cause in operation, and a knowledge of this can only be arrived at by a careful inquiry into the history and circumstances belonging to each case. The object to be attained is to allay the irritability of the stomach, and remove the source of

irritation, wherever it may be, that constitutes the primary cause of the complaint.

For allaying irritability of the stomach, the hydrocyanic acid is one of the most useful remedies. It may be given in an effervescing draught of bicarbonate of potash and citric acid or fresh lemon-juice which is better, and a drachm of the tincture of columba; or in a mixture with conium or hyoscyamus, and the carbonate of magnesia; or else in lime-water.

Creosote has been highly extolled as a remedy for vomiting, but general experience is to the effect that its value has been much overrated. In inflammatory conditions of the stomach it is calculated to aggravate rather than relieve the condition of the patient.

Opium or morphia will sometimes succeed in affording relief where all other measures have failed. A striking instance of this kind occurred not long ago amongst my in-patients at Guy's Hospital. A middle-aged man had been suffering from incessant vomiting for many weeks, and had become reduced to an extreme state of emaciation. His case was such as to lead to the opinion that malignant disease of the stomach existed, and a fatal result seemed rapidly approaching through the effects of sheer inanition. After a number of remedies had been prescribed in vain, half a grain of morphia was ordered to be taken, in the form of a pill, three times a day. The pill was retained, and its effect was almost miraculous. The vomiting ceased; and the patient, upon whose case so grave an opinion had been formed, and who seemed at the very verge of death, was restored so as to be able to leave the hospital in about three weeks' time. When opium and

morphia are rejected from the stomach, an opiate clyster or suppository may be employed.

Benefit is in some cases derived from remedies such as chloroform and chlorodyne. The hypo-sulphite of lime has been recommended in vomiting associated with the presence of *sarcinæ* in the vomited matters. It certainly has a destructive influence on the life of these and other such-like low members of organisation, but the development of *sarcinæ* is almost invariably accompanied with the existence of organic disease.

Attention must not be omitted to be given to the state of the bowels. These should be kept open by the administration, if necessary, of some mild form of laxative (all irritant purgatives must be avoided); or by the use—and this is often better—of emollient or purgative enemata.

A mustard poultice applied to the pit of the stomach is frequently attended with the best result. Where a more permanent counter-irritant action is required, a blister should be employed instead; and savin ointment may be used to keep the blister open. In some cases it may be desirable to establish a blister, and apply morphia to the blistered surface, instead of administering it by the mouth.

Ice is a most useful adjuvant in the treatment of vomiting. It often succeeds in allaying irritability of the stomach, and relieving the distress of the patient more than anything else. It should be broken into pieces, and placed by the bedside, so that it may be taken whenever the patient pleases.

In all cases it is of the first importance to pay strict attention to the regulation of the diet. It is no use putting food into the stomach that is sure to be imme-

diately rejected by vomiting. Harm can only result therefrom. As long as the stomach is totally intolerant of food it should be withheld, and, if necessary, nutrient enemata administered. By rest an opportunity is given for the restoration of the organ to a more natural state, or a less irritable condition. If any food can be retained, the quantity taken—whether a table-spoonful, dessert-spoonful, or teaspoonful—should be within the limit of what can be kept down. The quantity of food, in other words, should be reduced to that amount, whatever it may be, which the stomach is found capable of retaining, compensation being made for the reduction called for by increased frequency of administration. The food given should be of the most nourishing, easily digestible, and least irritating kind that can be found; and nothing comes up to what is required better than milk—an article of food provided for us by nature during our most tender age, and when the digestive organs are first called upon for their exercise of functional activity. Lime-water is often a useful addition to the milk, to enable it to be more easily retained. Bread, or some other farinaceous substance, should form the first other kind of food to be allowed.

Its instructive and telling nature, and the high estimation in which I hold the plan recommended, must form my apology for transcribing here the celebrated and often quoted account given by Dr. William Hunter of "The successful Cure of a severe Disorder of the Stomach by Milk taken in small quantities at once," in a communication contained in the sixth volume of the 'Medical Observations and Inquiries.'

"Many years ago," says Dr. Hunter, "a gentleman

came to me from the eastern part of the City, with his son about eight or nine years old, to ask my advice for him. The complaint was great pain in the stomach, frequent and violent vomitings, great weakness, and wasting of flesh. I think I hardly ever saw a human creature more emaciated, or with a look more expressive of being near the end of all the miseries of life. The disorder was of some months' standing, and, from the beginning to that time, had been daily growing more desperate. He was at school when first taken ill, and concealed his disorder for some time; but growing much worse, he was obliged to complain, and was brought home to be more carefully attended. From his sickly look, his total loss of appetite, besides what he said of the pain which he suffered, but especially from his vomiting up almost everything which he swallowed, it was evident that his disorder was very serious.

"Three of the most eminent physicians of that time attended him in succession, and tried a variety of medicines without the least good effect. They had all, as the father told me, after sufficient trial, given the patient up, having nothing farther to propose. The last prescription was a pill of solid opium; for in the fluid state, though at first the opiate had stayed some time upon his stomach, and brought a temporary relief, it failed at length, and like food, drink, and every medicine which had been taken, was presently brought up again by vomiting. The opiate pill was therefore given in hopes that it would elude the expulsive efforts of the stomach. It did so for a time; but after a little use, that likewise brought on vomiting. Then it was that his physician was consulted for

the last time, who said that he had nothing further to propose.

"Though at first the boy professed that he could assign no cause for his complaint, being strictly interrogated by his father if he had ever swallowed anything that could hurt his stomach, or received any injury by a blow or otherwise; he confessed that the usher in the school had grasped him by the waistcoat at the pit of his stomach, in a peevish fit, and shaken him rudely, for not having come up to the usher's expectation in a school exercise—that, though it was not very painful at the time, the disorder came on soon after. This account disposed the father to suspect, that the rude grasp and shake had hurt the stomach. With that idea he brought him to me as an anatomist, that an accurate examination might, if possible, discover the cause or nature of the disorder.

"He was stripped before the fire, and examined with attention in various situations and postures; but no fulness, hardness, or tumour whatever could be discovered: on the contrary, he appeared everywhere like a skeleton covered with a mere skin; and the abdomen was as flat, or rather as much drawn inwards, as if it had not contained half the usual quantity of bowels.

"Having received all the information that I could expect, and reflected some little time upon the case, I wished to speak with the father alone in another room; and, to give my patient some employment as well as refreshment, asked him to take a little milk in the mean time. But his father begged that taking anything into his stomach might be put off till he got home, because he was certain it would make him sick:

Just before we set out, said he, I gave him a little milk; but he was sick, and brought it all up in the coach before we had got many paces from the house.

"In the adjacent room I said to the father; This case, sir, appears to me so desperate, that I could not tell you my thoughts before your son. I think it most probable, no doubt, that he will sink under it; and believe that no human sagacity or experience could pretend to ascertain the cause of his complaint; and without supposing a particular or specific cause, there is hardly anything to be aimed at in the way of a cure: yet, dreadful as this language must be to your ear, I think you are not to be without hope. As we do not know the cause, it may happen to be of a temporary nature, and may of itself take a favorable turn: we see such wonderful changes every day in cases that appear the most desperate, and especially in young people. In them the resources of nature are astonishing.

"Then he asked me if I could communicate any rules or directions for giving him a better chance of getting that cure from nature which he saw he must despair of from art.

"I told him that there were two things which I would recommend. The first was not so important, indeed, yet I thought it might be useful, and certainly could do no harm. It was to have his son well rubbed, for half an hour together, with warm oil and a warm hand, before a fire, over and all around his stomach, every morning and evening. The oil, perhaps, would do little more than make the friction harmless as well as easy; and the friction would both

soothe pain, and be a healthful exercise to a weak body.

"The second thing that I was to propose I imagined to be of the utmost consequence. It was something which I had particularly attended to in the disorders of the stomach, especially vomitings. It was carefully to avoid offending a very weak stomach, either with the quantity or quality of what is taken down; and yet to get enough retained for supporting life. I need not tell you, sir, said I, that your son cannot live long without taking *some* nourishment: he must be supported to allow of any chance in his favour. You think that for some time he has kept nothing of what he swallowed; but a small part must have remained, else he could not have lived till now. Do not you think, then, that it would have been better for him if he had only taken the very small quantities which remained with him, and were converted to nourishment? It would have answered the end of supporting life as well, and perhaps have saved him such constant distress of being sick and of vomiting. The nourishment which he takes should not only be in very small quantity at a time, but in quality the most inoffensive to a weak stomach that can be found. Milk is that kind of nourishment. It is what Providence has contrived for supporting animals in the most tender stage of life. Take your son home, and as soon as he has rested a little, give him *one* spoonful of milk. If he keeps it some time without sickness or vomiting, repeat the meal; and so on. If he vomits it, after a little rest try him with a smaller quantity, viz., with a dessert or even a tea-spoonful. If he can but bear the smallest quantity, you will be sure of being able to

give him nourishment. Let it be the sole business of one person to feed him. If you succeed in the beginning, persevere with great caution, and proceed very gradually to a greater quantity, and to other fluid food, especially to what his own fancy may invite him; such as smooth gruel or panada, milk boiled with a little flour of wheat or rice, thin chocolate and milk, any broth without fat, or with a little jelly of rice or barley in it, &c. &c.

"We then went in to our patient again; and that he might be encouraged with hope, and act his part with resolution, I repeated the directions with an air of being confident of success. The plan was simple, and perfectly understood. They left me.

"I heard nothing of the case till, I believe, between two and three months afterwards. His father came to me with a most joyful countenance, and with kind expressions of gratitude told me, that the plan had been pursued with scrupulous exactness, and with astonishing success—that his son had never vomited since I had seen him—that he was daily gaining flesh and strength, and colour and spirits—and now grown very importunate to have more substantial food. I recommended the change to be made by degrees. He recovered completely; and many years ago he was a healthy and very strong young man."

Following this account is an appendix under the form of a letter from Mr. William Hey, of Leeds, to Dr. Hunter, containing reports of four cases in which Dr. Hunter's plan of treatment had been put into practice with the same success as in the case above. My own experience is in the highest degree confirmatory of the value of the plan. Several cases have

come before me in my hospital practice, where, through its agency, all that could be desired has been attained, whilst the patients had been under medical treatment for some time previous to admission, and nothing had given them relief.

ERUCTATION.—RUMINATION.

Gaseous, liquid, and solid matters are sometimes expelled from the stomach and raised into the mouth without any visible muscular effort, such as occurs in vomiting. This eructation or belching is a common symptom of indigestion. Something suddenly rises from the stomach into the mouth without any previous feeling of nausea. The phenomenon results from a contraction of the muscular fibres of the stomach, a relaxation of the cardia, and a reversed peristaltic action of the œsophagus, without the co-operation of the abdominal muscles, as in vomiting. An irregular muscular contraction produced by a morbid stimulus, usually the result of defective or impaired digestion, may be looked upon as forming the rationale of its occurrence.

The eructation of gas is a very common circumstance, and may depend upon the nature of the ingesta without the existence of any deviation from health. In cases of flatulence the eructation of large quantities of gas may take place, forming a source of considerable inconvenience and sometimes annoyance, although affording relief to the feeling of distension that exists.

Sometimes the gas discharged is of a fetid character —may be so foul, indeed, as to render the person's presence almost unbearable to others. Owing to im-

perfect secreting action, or a defective state of the gastric juice, putrefactive changes are allowed to take place amongst the contents of the stomach, and as the result sulphuretted hydrogen and such-like gaseous products of decomposition are evolved. Hence, the belchings presenting the smell of rotten eggs. An emetic by emptying the stomach at once relieves the condition for the time.

The fluids eructated vary much in character and quantity. Sometimes the patient is troubled with the rising of a small quantity of liquid into the mouth during digestion which may be more or less tasteless, saltish, acid, bitter, or acrid. In acidity of the stomach the fluid brought up may be so sour as quite to set the teeth on edge. In cardialgia or heartburn the eructation is attended with the rising of a small quantity of fluid to the back of the mouth, of so acrid a character as to produce a most unpleasant burning sensation in the parts over which it has passed. In pyrosis or waterbrash large quantities of an almost tasteless or slightly saltish fluid are brought up without any effort or distress. The patient is often astonished at the amount of "clear water" that is thus brought off from the stomach. Infants at the breast sometimes suddenly reject the milk that has been swallowed. Without any warning and without any appearance of effort, the milk suddenly gushes from the infant's mouth. This phenomenon has been called regurgitation, but I cannot see that it essentially differs from what is known as eructation.

The eructated material may consist of undigested or of imperfectly digested food. The rising of a little food into the mouth is not a matter of uncommon

occurrence. In some of the cases that especially occur amongst hysterical females, and that are described as cases of vomiting, the food that is taken is returned by a process rather akin to that of eructation than that of vomiting: the matters being thrown off without any appearance of effort, and without any feeling of nausea or distress. It was by eructation that Montegre discharged the contents of his stomach at will. Even when fasting, as in the morning on rising, he could eject in this way a clear watery fluid from his stomach.

The treatment of eructation must be regulated by the nature of the rejected matter. In the eructation of ordinary flatus, when it amounts to an inconvenience, the remedies recommended for "flatulence" must be employed. Flatulent eructations of a marked kind are common in hysteria and hypochondriasis; and in such cases, besides carminatives, agents for combating these affections are called for. Fetid eructations will in general be found to be counteracted by pills containing a quarter or half a minim of creosote given with each meal. Simplicity of diet should also be conjoined—hashes, stews, and rich made dishes being especially productive of a foul stomach. Should the rejected matter be of a fluid nature, the treatment for acidity, heartburn, or pyrosis, will have to be put in practice, according to the circumstances of the case. If solid matter is raised, careful mastication and moderation in eating must be enjoined, and an improvement of the digestive power effected.

Some few instances are on record of persons who have been in the regular habit of returning the food that has been swallowed, and subjecting it to a second

mastication, as is done by the ruminant animal. Dr. Copland * has placed together a humorous collection of recorded cases of human rumination; and has further described some instances (amongst which one seems to have been of a well-marked character) that have fallen under his own observation.

Fabricius, who furnished two of the earliest instances of human rumination recorded, believed, we are told, the subjects of it to be endowed with a double stomach, and that other bestial attributes might in process of time appear in them or their descendants. His first case is that of a nobleman, who always returned his meals, in general about an hour after they had been taken, to undergo a second and more deliberate mastication. The father of this person is stated to have had a horn growing from his forehead; and the remark is gravely made, that although the son did not inherit his father's horn, yet he possessed the accompanying faculty of rumination. His second case is that of a monk, who, it is said, combined the bestial attributes of both the father and son above referred to, having had, in addition to enjoying the faculty of rumination, his forehead adorned with a couple of horns.

Sennert has left behind him an account of a man of forty, who possessed the ruminating faculty from a child. Learning that this person had lost his mother when an infant, and had been fed with milk warm from a cow, he found no difficulty in accounting for the affection, his conclusion being that he sucked it in with his nurse's milk!

Recchi, it is said, seated over his cups with his friends, at the conclusion of dinner, was always obliged

* 'Dictionary of Practical Medicine.' art. "Rumination."

to retire, about half an hour after the meal, into a remote corner of the apartment, to ruminate the food he had taken. Being asked how he became obliged to indulge in this propensity, he answered that from a boy he had been subject to acid eructations; and that after having reached his thirtieth year he found it impossible to resist admitting into his mouth the food that constantly gurgitated from his stomach. Being further interrogated, whether the second mastication of his food afforded him any gratification, "Indeed," he replied, "it is sweeter than honey, and accompanied with a more delightful relish."*

Dr. Copland states that the first case which came under his own observation was treated in 1819 and 1820, and that since the publication of it in the forty-fifth volume of the 'London Medical and Physical Journal,' two others—one of them in a medical man—have been treated by him; and that he has reason to believe that instances of partial or occasional rumination are not so rare in the human subject as is generally supposed. The report given by Dr. Copland of the fully developed case, which continued for some time under his care, runs as follows:

"The patient was a married man of about twenty-seven or twenty-eight years of age. Rumination took place after all his principal meals. His appetite was always good, and his food was taken in large mouthfuls, was masticated hastily and imperfectly, and swallowed eagerly, chiefly in order to resume his avocations. There was no thirst. His bowels were habitually costive. His sleep was sound.

"Usually rumination commenced from a quarter of

* Dr. Copland, op. cit.

an hour to an hour after a meal. At its commencement a sense of fulness was felt at the cardia, followed by a fuller respiration than usual. As sôon as inspiration was completed, a bolus of the unchanged food rose rapidly from the stomach, during the expiratory act or preceding this act; and so rapidly did expiration succeed to regurgitation of the alimentary bolus, that the latter appeared as part of the expiratory act. The rumination process was never accompanied, at any time, with any degree of nausea, nor with pain or disagreeable sensation. The returned alimentary bolus was attended by no unpleasant flavour, was in no degree acidulous, was equally agreeable, and was masticated with greater pleasure, and much more deliberately, than when first taken.

"The whole of the food taken at any one meal was not thus returned for mastication—only the part which had undergone this process insufficiently, and which often constituted the greater part of the aliment. That taken at the commencement of a meal was generally first disgorged; but this order was sometimes not observed, much depending upon the articles partaken of, and their comparative degrees of comminution and digestibility. The more fluid portions of a meal were not always returned, unless along with the more solid or imperfectly masticated parts; and it was often then observed, if a considerable time had elapsed from their deglutition, that the former was more or less acid, whilst the latter possessed the same taste and flavour as when first swallowed. When the stomach was distended suddenly by a large meal, the fluid as well as the more solid contents were generally regurgitated, and again swallowed after more or less mastication."

The possession of a double stomach was associated by some of the older authorities with the occurrence of the phenomenon of rumination. Actual dissection, however, as might be expected, has been found to lend no support to such a proposition, and nothing structurally has been discovered to account for the affection. Peter Frank was of opinion that in persons who suffer from eructations and are voracious, rumination is induced by a bad habit, the not unpleasant taste of ruminated matter offering an encouragement to the repetition of the process. The affection is generally accompanied with derangement of the digestive organs, flatulence, and especially a quick or voracious mode of eating. This latter seems to form the chief exciting cause, the predisposing cause being a morbid irritability of the stomach. The affection in its fully developed condition seems to be partially, and partially only, under the control of the will. In Dr. Copland's case, above cited, when the ruminating process was prevented, as it was, by the supervention of sound sleep after a meal, or voluntarily suppressed, the ingesta were not returned for some hours, were then acid or often acrid and bitter, and were occasionally regurgitated in so large a quantity as to fill, or even more than fill, the mouth.

As regards treatment, more, we are told, may be expected from careful mastication and attention to slowness and moderation in eating than from anything else. Attention should also be paid to the state of the secretions and the bowels.

PERVERTED APPETITE.

By the sense of appetite we are made conscious that food is required, and are prompted to take it. The sense also guides us as to the amount proper to be taken, if not counteracted by variety, which is gratifying to the palate, and so creates a desire that must not be mistaken for appetite. In its more advanced stage, the feeling which tells us food is wanted constitutes hunger. Perverted conditions of the appetite occur, and are of three kinds:—1, excessive appetite; 2, loss of appetite; and, 3, vitiated appetite.

An inordinate appetite, or *bulimia*, may be habitual and proceed from a gluttonous disposition. It frequently arises from worms in the alimentary canal; or it may be caused by grave disease existing either in the digestive organs, or some other part of the system. Inordinate appetite is often observed in organic affections of the stomach, pylorus, and mesenteric glands. It forms one of the symptoms of diabetes mellitus, and is sometimes observed in chronic disease of the brain—that form of it which leads to insanity accompanied with general paralysis.

Anorexia, or loss of appetite, occurs as a symptom of dyspepsia, and with various other morbid conditions of the system. The state may be such that the very sight

of food or the thought of eating may suffice to excite a feeling of loathing or disgust.

The falling off of the appetite that is found to be experienced under exposure to heat, as during the hot weather of summer, or from residence in a tropical climate, must not be mistaken for an unnatural occurrence. It is in wise harmony with the requirements of the case, there being a much less demand for food during hot than cold weather.

Vitiated appetite, or *pica*, constitutes that state in which there is a depraved fancy or craving for unnatural substances as food. It is sometimes noticed in children, and frequently in idiots. It likewise forms an occasional phenomenon belonging to pregnancy, hysteria, and chlorosis. Fancies for all sorts of things have in their turn existed, and the objects of desire have sometimes been of the most incredible and disgusting description.

The treatment of these perversions of the appetite will depend upon the nature of the cause producing them. General principles must point to the appropriate course to be adopted.

PAIN AND OTHER MORBID SENSATIONS CONNECTED WITH THE STOMACH.

Beyond experiencing a feeling of appetite, or in its more exalted form, of hunger, when the system is in want of food, and a sense of satiety when enough food has been taken, we ought to experience no sensation referable to the stomach. Under natural circumstances the process of digestion is performed without giving rise to any consciousness of its progress. When derangement, however, exists the person becomes conscious, and often most painfully so, that he has such an organ as a stomach, and such a function to perform as that of digestion. Pain, or if not pain uneasiness, under some shape or other, is one of the most frequent concomitants of deranged digestion; and sometimes it exists without any other manifestation of perverted action.

The morbid sensations referable to the stomach are exceedingly numerous and varied in their character. By far the most common form of morbid phenomenon connected with sensibility is a sense of fulness or tightness—a feeling of distension or of weight or heaviness at the pit of the stomach. The least quantity of food may excite this sensation in the dyspeptic—an unnaturally voluminous meal will occasion it in the healthy subject.

The opposite sensation is a feeling of emptiness or

sinking—a sense of vacuity at the pit of the stomach. This occurs as the natural consequence of want of food; but it may also be experienced when the supply is plentiful. Patients affected with tapeworm complain of frequently experiencing this sense of emptiness; and in some cases of diabetes mellitus I have known it urgently complained of, even whilst food is being constantly administered, and where no evidence has existed, judging from the state of the body, of there being any defect of nutrition. A sense of constant emptiness at the pit of the stomach, it is true, is one of the ordinary symptoms of diabetes, where the disease is allowed to run on in a severe form and emaciation of the body is advancing; but I have upon a few occasions also met with it in quite a different form of the complaint: in stout and elderly persons, for example, who have been passing scarcely beyond or not beyond the natural quantity of urine, and this not much charged with sugar. In the cases I am alluding to the distress has been such, from the sense of emptiness experienced, as to cause the patients frequently to exclaim to their friends that they felt sure they were sinking.

Nausea, or feeling of sickness is that distressing sensation which generally precedes vomiting. It may be experienced, however, without being followed by such a result. It forms a frequent accompaniment of dyspepsia.

Another morbid feeling, not unfrequently encountered, is a burning sensation or a sense of heat at the pit of the stomach. It forms one of the phenomena of heartburn, and may be also experienced in pyrosis or water-brash.

The morbid sensation encountered may constitute

what is understood as falling under the denomination of actual pain, and pain of various kinds may occur. The pain, for instance, is sometimes described as of a dull, aching character; sometimes a burning pain; sometimes a gnawing pain; and sometimes a sharp, colicky, or griping pain. Various other expressions are also used to denote the kind of pain experienced.

The occurrence of severe pain of any kind is as a rule popularly spoken of as spasm or cramp of the stomach. It *may* be to spasm that it is due, as in the pain produced by flatus; sometimes the pain produced by indigestible articles of food, or irritating matter in the stomach; and in that occurring as an accompaniment of lead colic. But pain likewise owes its origin to inflammatory and organic affections of the stomach; and may further arise, without any associated structural disease, from the condition of the nerves of the organ, so constituting what may be looked upon as a kind of neuralgia. This last form of pain will presently receive attention under the name of gastrodynia.

An attack of severe pain occurring in a gouty subject is frequently put down as gout in the stomach. It does not seem clear, however, that such an affection as "gout in the stomach," strictly speaking, has been made out to exist. Dr. Brinton, in his work on the stomach,* devotes a chapter to answering the question, which years ago, he says, he often used to ask himself, and since then has had so often pressed upon him by others—What is gout in the stomach? After examining the various claimants to this title he remarks, "Is there any gout in the stomach left after the subtraction

* 'Lectures on Diseases of the Stomach, 1864.

of these various affections? I can only say that I know of no such case—have never seen one—have never been able to get trustworthy evidence of one from some of the most accomplished physicians living, or from the best records." Sir Thomas Watson says—"You will meet sometimes with what is called *spasm* of the stomach (and I suppose it is such) in gouty people, who are then said to have gout in the stomach. The pain comes on in sudden and severe paroxysms, and is removable in general by laudanum and stimulants—brandy, for example—or by the mustard poultice. On these cases, however, we look with jealousy and apprehension. In some instances the attack is really inflammatory, and would then be aggravated by a stimulant treatment." Further on he suggests that it will always be well when a reputed attack of gout in the stomach occurs to inquire whether any indigestible food has been lately taken; "for *gout* (so called) in the stomach has sometimes turned out, under the test of an emetic, to have been nothing more than *pork* in the stomach."

The form of pain that is comprehended under the terms gastrodynia (γαστήρ, stomach: ὀδύνη pain) and gastralgia (γαστὴρ, stomach; ἀλγέω, I suffer pain) often bears the aspect of an individual or independent affection. It may be regarded as of the character of neuralgia, and exists, not only unassociated with any evidence of structural disease, but sometimes also as the only manifestation of gastric derangement. It is a very common affection amongst the poor, and is a great deal more frequently met with in the female than in the male sex. The nervous temperament and the hysterical, hypochondriacal, and gouty dispositions pre-

dispose to the affection. A close sympathy exists between the stomach and the uterus, and gastrodynia is a frequent attendant on uterine derangement.

The pain of gastrodynia is oftentimes exceedingly severe. The situation to which it is referred is the pit of the stomach; and, if the question be put, it will be found that complaint is made of its extending through the body to the back between the shoulder-blades. As the loins form the part of the back to which pain from affections of the kidneys is referred, so the part between the shoulder-blades forms the region for pain associated with stomach affections. Much variety exists respecting the period of occurrence and the duration of the pain in different cases. In general it is at a variable period after taking food that it comes on, and it may afterwards last for some hours. Sometimes it is upon an empty stomach that the pain is experienced, and taking food affords relief. The pain may come on suddenly, and as suddenly disappear; the patient during the interval enjoying perfect ease.

Gastrodynia is not an affection that endangers life; but it is often a most wearisome one to bear, and a difficult one to cure. It may be difficult at first to distinguish the pain of gastrodynia from that of chronic inflammation, ulceration, and malignant disease; but in a more advanced stage of the case the diagnosis, as a rule, is easy enough. In gastrodynia the pain is not aggravated, but even generally, on the contrary, eased by pressure. It is unattended with tenderness or fever, and does not lead to the production of that emaciation and cachexia which form accompaniments of structural disease.

In the treatment of gastrodynia a careful investiga-

tion of the patient's case must be made, and attention, in the first place, directed to rectifying any functional error that may be found anywhere to exist.

When gastrodynia is accompanied, as it often is, with a coated tongue and other evidence of gastric derangement, the hydrocyanic acid with carbonate of magnesia and conium, in peppermint-water or some such carminative vehicle, may be administered; or hydrocyanic acid with carbonate of soda or potash, rhubarb, and calumba.

Bismuth and the nitrate of silver exert a special curative influence in cases of gastrodynia. They often afford relief to the pain when every other agent has failed. A granular effervescing citrate of bismuth is made, and forms an elegant preparation. An old and effective formula from the Guy's pharmacopœia is a combination of nitrate of bismuth with carbonate of soda and powdered conium-leaves. In the new edition hydrochlorate of morphia is substituted for the conium.

The nitrate of silver was introduced by Dr. James Johnson, who had been himself a martyr to stomach complaints. It may be given in the form of a pill, beginning with a quarter of a grain or a half-grain dose, three times a day. Its employment cannot be continued for more than two or three months without a risk of producing a darkening effect upon the skin.

Dr. Abercrombie extolled the sulphate of iron with aloes and aromatic confection in cases of gastrodynia, his statement being that he had found nothing of more general utility than the sulphate of iron in doses of two grains, combined with one grain of aloes

and five grains of aromatic powder, taken three times a day.

As in the treatment of the other forms of gastric derangement, careful attention must be paid to diet and the various other hygienic requirements.

FLATULENCE.

Flatus or gas is apt to accumulate in the stomach and give rise to a condition which forms one of the most common phenomena of deranged digestion. Three sources exist for gaseous matter encountered in the stomach:

First, it may be derived from air reaching the stomach by being swallowed.

Secondly, it may form a product of secretion or elimination from the blood by the mucous membrane. The presence of gas in the swimming bladder of the fish sufficiently shows that gas may be eliminated in this way.

Thirdly, it may be generated as a product of fermentation or decomposition from the ingesta or other contents of the stomach. With a weakened state of the digestive powers, ordinary fermentation and decomposition are allowed to come into play to an extent that is not permitted under the existence of a more vigorous state. We have thus, it may be considered, an explanation of the common mode of production of flatulence. From a want of tone at the same time existing in the muscular fibres an enormous distension of the stomach may happen to be permitted. In cases of extreme debility, whether as the result of acute or of

chronic disease, the accumulation of gas that is thus allowed to take place may constitute a formidable condition to deal with.

The presence of gas in the alimentary canal must be described as constituting the ordinary condition. It is only when this gas accumulates, so as to occasion inconvenience, that a person can be said to be suffering from flatulence. In stomach flatulence a swelling presents itself in the region spoken of as constituting the pit of the stomach. Complaint is made that this part feels tender to the touch, and the clothes are often loosened to obviate the distress occasioned by pressure. The swelling gives a tympanitic resonant sound on percussion. In proportion as the accumulation advances the action of the diaphragm becomes impeded, and the breathing embarrassed; and from the distension arising, a painful sense of oppression and anxiety is experienced. Attempts are made to break off the "wind" by eructation, and immediate relief is obtained when this is accomplished. In popular parlance, a patient in such a state is said to be suffering from "windy spasms."

It is especially towards the evening that the distension from flatulence as a simple dyspeptic phenomenon is most marked. No decided inconvenience may be experienced during the fore part of the day, but as the evening arrives, and the stomach has been taxed with the work thrown upon it during the day, the flatulent distension with its accompanying distress comes on. With some dyspeptics the flatulence is induced by emptiness of the stomach. A meal for instance happening to be delayed a little beyond the accustomed hour, an attack of "wind on the stomach" is the result. In

these cases a due regulation of the periods of taking food will often suffice to obviate the complaint.

Infants are very subject to flatulence, especially when their natural food is taken too hastily, and when food other than that provided for them by nature is given to them. Mothers and nurses are sufficiently familiar with this infantile trouble, and have their popular remedies for it. The digestive organs are of necessity in a complete state of functional inactivity, during intra-uterine life. A call for work is made upon them, all of a sudden, and often beyond what is intended by nature, immediately after birth. Now, it is not surprising that a betrayal of weakness should be of common occurrence at this period.

The object to be attained in the treatment of flatulence is the improvement of the digestive energy and the muscular tone of the stomach. Digestive solution without spontaneous decomposition is what is wanted, and the muscular power should be such as to be capable of expelling by eructation whatever gas may chance to be produced, instead of allowing it to accumulate. The food should be easy of digestion, and taken at regular intervals. Vegetable articles, from their difficulty of digestion, are not unlikely to occasion flatulence with a weakened stomach.

A class of remedies in high repute in flatulence consists of the warm aromatics—or carminatives as they are technically styled. They act in two ways—by exciting muscular contraction, and so effecting an expulsion of the flatus that has been generated; and by checking the occurrence of changes of ordinary fermentation and decomposition in the food contained in the stomach, and so diminishing the subsequent pro-

duction of gas. The relief that they sometimes afford is so marked and instantaneous, as to have suggested the idea of their acting like a charm, and thus arose the employment of the term *carminative* (*carmen*, a charm). The relief, however, produced by carminatives is only likely to be of a temporary nature. To obtain permanent relief a more healthy state of the *primæ viæ* must be induced by the remedies suggested by a careful consideration of the circumstances of each case.

Friction of the abdomen with a stimulating liniment will assist the carminative in its action. In extreme cases of tympanitic distension an injection of assafœtida, turpentine, or rue, may be resorted to.

HEARTBURN (CARDIALGIA).

By cardialgia or heartburn is commonly understood that burning sensation at the pit of the stomach which is generally attended with the rising or eruction of a small quantity of fluid, of so acrid a character as to produce a most disagreeable sensation, referred to the parts over which it passes, but particularly to the back of the mouth. Often the fluid eructated is not only acrid, but intensely bitter to the taste, and may produce quite a shudder as it rises. It is frequently brought up with an eructation of gas, and may be so small in quantity as not to reach farther than the back of the mouth.

Cardialgia occurs at the middle and advanced periods of digestion, and rich living is a common source of its production. Dr. Leared is of opinion that butyric acid, either ingested, ready formed, as in pastry, &c., or formed as the result of defective digestion, in the stomach, is the agent which gives rise to the sensation; and in support of his view, he says that pure butyric acid, brought in contact from above with the fauces and œsophagus, produces a sensation pronounced by competent judges to be identical with that of heartburn. I am inclined to think, from personal experience, that certainly the burning sensation at the pit of the stomach is sometimes due to a retrograde flow

of bile into the cavity of the viscus. After having been subject for some time to a frequent recurrence of the sensation of heartburn, and with it thus fresh before me, I was struck at perceiving the same burning sensation at the pit of the stomach that belongs to it come on during the occurrence of vomiting efforts, the result of sea-sickness, after all the food had been some time previously discharged from the stomach. The rejection following the arrival of this burning sensation was strongly tinged with bile, whilst no appearance of bile had been noticed before.

The treatment that is usually successful for heartburn consists of the administration of alkaline agents conjoined with a proper regulation of the quantity and quality of the food, A combination of the carbonate of soda or ammonia with rhubarb and magnesia, or with rhubarb and a mild bitter, as the calumba, may be advantageously given; or sometimes the liquor potassæ in a bitter infusion. As alkaline agents, the seltzer, Vichy, and Vals waters form agreeable and useful remedies. Heartburn which is habitual or of long standing is often more effectually relieved by acids than alkalies, and the nitric acid is the best for the purpose.

WATER-BRASH (PYROSIS).

This constitutes an affection attended with pain, and the eructation of fluid in considerable quantity from the stomach. Dr. Cullen, whose experience of the complaint was large, his field of observation being in Scotland, where it is much more prevalent than in England, has left a faithful description of its phenomena. Its paroxysms, he says, "usually come on in the morning and forenoon, when the stomach is empty. The first symptom of it is a pain at the pit of the stomach, with a sense of constriction, as if the stomach were drawn towards the back. The pain is increased by raising the body into an erect posture, and therefore the body is bended forward. The pain is often very severe; and, after continuing for some time, it brings on an eructation of a thin watery fluid in considerable quantity."

The fluid discharged is usually almost tasteless, but sometimes more or less acid or sour. Patients often complain that it feels cold as it rises into the mouth, notwithstanding that the pain at the epigastrium which has preceded its eructation is of a burning character. The eructation is repeated several times without at first affording relief to the pain; ultimately, however, the pain ceases, and the paroxysm is at an end. The paroxysms vary considerably in duration in different individuals, and likewise the different paroxysms in the same individual. Their period of recurrence is

also uncertain. Sometimes, for instance, there may be a paroxysm every day for some time; whilst at other times the paroxysms occur irregularly at more distant periods. They are unaccompanied with any nausea, retching, or febrile excitement.

Pyrosis is an affection especially belonging to the middle period of life. It is seldom encountered in children, and rarely in advanced age. Women are more subject to it than men, and unmarried women than the married. After it has once occurred it is very apt to return. From its being more common amongst the poor than the rich, the extensive use of farinaceous food has been assigned as one of its exciting causes. In Scotland, and some other northern countries—as Norway, Sweden, and Lapland—it constitutes a very common complaint—infinitely more so than in England. This is thought to be attributable to the rye, barley, or oatmeal food that is consumed in the place of bread. Nearly half the men and women living near the mountains in Lapland were, according to Linnæus, in his time, the subjects of pyrosis.

The precise nature of the fluid discharged in pyrosis and its source have not been as yet satisfactorily ascertained.

Frerichs, from his examination of vomited fluids, has ascertained that in some disorders of the stomach the fluid rejected consists of saliva. The salivary glands, being sympathetically irritated, secrete an abundance of saliva, which is swallowed and subsequently rejected. The fluid has been found to present all the characters of saliva in these cases. In reaction it has been generally alkaline, but often neutral, rarely acid. It has contained a large quantity of the sulphocyanides, and

under the requisite conditions has rapidly converted starch into sugar.

Montegre, who possessed the faculty of discharging the contents of his stomach at will by eructation, sometimes ejected half a tumblerful of liquid before anything had been taken in the morning. This he looked upon as gastric juice; but it is evident from the properties he described it as possessing, and from what is now known concerning the action of the secreting follicles of the stomach, that it was not such. He remarked that the rejected fluid differed in reaction at different times, acidity being a character that by no means invariably belonged to it; and that it resembled—in fact seemed identical with, saliva. It evidently consisted of saliva which had been swallowed, and had accumulated in the stomach; and such is doubtless often the source of the fluid matter rejected from the stomach when in an empty state as regards food.

The characters of the fluid raised in pyrosis are not those of gastric juice; but fluid, other than gastric juice, it may be inferred, can be poured out under certain circumstances from the walls of the stomach. In some cases of uræmia belonging to Bright's disease, large quantities of fluid are thrown off from the stomach by vomiting, which may be presumed to be derived from the stomach itself. Lehmann says that the rice-water fluid vomited in cholera, both in its physical and chemical properties, is almost perfectly identical with the fluid vomited in uræmia, and that the reaction of these fluids may be either acid, neutral or alkaline. Now, such fluids differ as much from the physiological product of secretion as does that discharged in pyrosis; and presuming the one to be

derived from the stomach, a parallel is offered which renders it not unreasonable to assume that the other may be derived from the stomach also. A catarrhal state of the stomach is sometimes regarded as constituting the condition associated with pyrosis. Broncorrhœa is an affection attacking the respiratory mucous surface which presents a close analogy in character to pyrosis.

The suggestion that the fluid eructated in pyrosis results from disease of the pancreas, and constitutes a product of secretion of this gland, which has passed by regurgitation into the stomach, seems to me too hypothetical to require any special comment.

I have examined some specimens of fluid discharged in cases of pyrosis, with the view of ascertaining if it possessed digestive properties. In one instance the fluid was thrown up, mixed with a little food. It presented a strongly acid reaction, and evidently contained a quantity of good gastric juice, as it produced a rapid digestive effect upon the hind legs of a frog suspended in it at the proper temperature. Upon another occasion a portion of two quarts that had been thrown up was examined. As this was only faintly acid, it was treated with strong hydrochloric acid in the proportion of twenty minims to the ounce. At the end of six hours there was only slight evidence of digestive action apparent, which shows that the liquid could have contained scarcely any pepsine. In another instance some fluid was taken that was clear and neutral. It was treated with acid, and at the end of eight hours had only produced a moderate digestive effect. This, therefore, again, contained very little active pepsine.

In connection with these observations I have per-

formed some experiments on the solution and removal of pepsine by water from the healthy stomach. Forty-eight hours after food had been given to a dog, half a pint of water at the temperature of the body was injected through an œsophageal tube into the stomach. In a quarter of an hour's time the life of the animal was destroyed, and the liquid immediately collected from the stomach. The organ was quite devoid of food, but found to contain a little hair and some small fragments of straw. The liquid presented a strongly acid reaction; and, experimented upon alone, gave evidence of possessing digestive power. In another experiment, at the same period after the administration of food, six ounces of water at the temperature of the body were introduced into the stomach, and in five minutes' time the animal was killed. The contents of the stomach, which were immediately collected, were found neutral to test paper, as also was the mucous surface. Treated with an acid, the liquid obtained produced a strong digestive action in respondence to the test that was employed. In the first experiment it would seem that the water during its quarter of an hour's sojourn in the stomach had excited a little flow of acid secretion from the follicles; whilst in the second, where five minutes only were allowed, pepsine was dissolved out from the mucous surface, but no acid had made its appearance.

Pyrosis, as a rule, only constitutes a functional disorder, and is not in itself a grave affection. It sometimes, however, occurs as a concomitant of organic disease, upon the nature of which the gravity of the case will then depend. Persons who have once been affected with pyrosis are very apt to experience a recurrence.

Opium is a remedy to which pyrosis generally yields. It relieves the pain; and, by allaying the morbid irritability of the stomach, checks the excessive secretion, which forms the prominent feature of the complaint. Sir Thomas Watson recommends opium in combination with an astringent, and says that the compound kino powder of the London Pharmacopœia is an admirable remedy for pyrosis. In the out-patient department of a metropolitan hospital, the physician is frequently called upon to treat this affection, and the prescription I am in the habit of ordering at Guy's and am not disposed to forsake, is one containing opium in combination with a bitter. The following is the formula employed, and such is the success with which it has been used, that I am frequently remarking to students attending in the out-patient room that I have rarely, if ever, known it fail in rapidly affording relief:

℞ Liquoris Opii Sedativi, ℥viij;
Inf. Gentianæ co., ℥j.
Misce, fiat haustus ter quotidie sumendus.

It often happens that other indications of gastric derangement accompany pyrosis. These will require their appropriate treatment as soon as the pyrosis has been subdued. Any article of food that is known to constitute an exciting cause of the complaint must be abandoned, or the relief afforded by treatment will only be of a temporary description.

ACIDITY.

Disordered digestion is sometimes attended with acidity of the stomach as its prominent symptom. The person experiences, in some instances occasionally only, in others almost constantly, a sour taste in the mouth. Acid eructations occur whilst digestion is going on, and the acidity of these eructations may be such as to set the teeth on edge. If the condition exists for some time, the teeth indeed become acted on and destroyed. Everything that is taken may be found to "turn more or less sour on the stomach;" but it is discovered that some articles of food are more productive of acidity than others. Vegetables, pastry, sweets and fruit, for example, are of this class. It sometimes happens that it is only after partaking of articles of this kind that the acidity is experienced. In the gouty diathesis a predisposition exists to the occurrence of this derangement.

It is well known that the saccharine principle is convertible by a particular kind of fermentation into acid. This conversion being permitted to occur within the stomach, through the existence of a defective state of its secretion, will account for some of the acid generated: namely, that which is specially produced by food of a saccharine and farinaceous description. But

marked acidity is in some cases experienced after the exclusive consumption of animal food; and hence it must be inferred that an excessive elimination of acid as the result of secretion may constitute also a source of the complaint.

Under healthy circumstances, changes of ordinary fermentation and putrefaction are not permitted to take place within the stomach, on account of the antiseptic power which the gastric juice enjoys; but when gastric juice imperfect in quality or deficient in quantity is secreted, fermentative changes in the food fail to be prevented from occurring; and so, the production of acid results. Again, from obstruction in the neighbourhood of the pylorus, or from some other cause, the food may be delayed for too long a time within the stomach, and the generation of acid that would not otherwise have taken place be permitted.

A morbid irritation of the stomach arising from disease, as from ulcer or cancer; or from the presence of indigestible articles within its cavity, may lead to an undue action of the secreting apparatus; and thus, an excessive outpouring of acid. The irritation resulting from disease may even cause gastric juice to be secreted during an empty state of the organ. Further, a source of irritation existing in some other part may affect the stomach in a reflex manner, and cause like direct irritation of the organ, a flow of gastric juice to take place without the usual stimulus being supplied. Such, for example, has been found to occur during the passage of gall stones through the bile ducts; and in the gastric disorder so common in organic diseases of the brain and tubercular disease of the lungs.

Alkalies and the alkaline earths—as the carbonates of soda, potash, and lithia; magnesia; and lime water—taken about two or three hours after a meal, by neutralising the excess of acid existing, afford a temporary relief to the complaint. The fluid magnesia (Liq. Magnesiæ Carbonatis of the British Pharmacopœia) forms an agreeable and serviceable antacid. The Vichy, Vals, Seltzer, and lithia waters, may often also be advantageously resorted to. By the continued administration of these remedies, a permanent removal of the morbid condition may be oftentimes brought about, but in other cases a temporary relief is all that continues to be afforded; and there are many persons who are constantly in the habit of resorting to the use of the carbonate of soda, which is the popular remedy employed, to correct their acidity of stomach.

Where the alkaline treatment fails, the mineral acids, by acting as tonics and improving the digestive power will sometimes effect a cure. The nitric acid in particular, says Abercrombie, is often found to be one of the best correctors of acidity. Where gout exists, colchicum is likely to do good.

As in the treatment of the other manifestations of deranged digestion, attention must be paid to the food and drink that are taken. A careful regimen will often succeed by itself in removing; and, if it do succeed in removing, will always lessen the complaint. Vegetables, fruit, pastry, and sweets, being the articles most productive of acidity, are to be looked upon as the things particularly to be avoided. Toasted and pulled bread agree better than bread of the ordinary form. Of animal food, broths and soups are the most

likely to turn sour on the stomach. Dry sherry and brandy and water form the liquids the least likely to disagree. Sweet ales and imperfectly fermented wines are almost sure to provoke an aggravation of the complaint.

INTESTINAL DIGESTION.

The agents concerned in intestinal digestion are the parts belonging to the intestinal canal, and the secretions of two large glands — the pancreas and the liver.

The intestine completes the alimentary canal below the stomach. It is physiologically and anatomically divided by a valvular orifice (ileo-cœcal) into two portions, named, from their difference in size, the small and large intestine. The small intestine forms the upper and considerably the longer portion of the two. It measures, in the adult human subject, about twenty feet in length. It is disposed in coils or convolutions in the centre of the abdomen, and attached in front of the spine by a process of peritoneum called the mesentery. The large intestine measures about five feet in length. Beginning at the right iliac fossa, it passes round the abdomen, describing a horse-shoe shaped bend around the convolutions of the small intestine occupying the middle of the abdomen.

The small intestine presents a regular or uniform surface, a character by which it is distinguishable at a glance from the large. Anatomists subdivide it into three portions, named respectively, proceeding from above downwards, the *duodenum*, *jejunum*, and *ileum*.

The duodenum is the shortest and widest of the

three subdivisions. It only measures about ten inches in length, which is equivalent to twelve finger breadths —from which has arisen the name it bears. In its course it receives the secretions of the liver and pancreas, and its walls are occupied with little compound glandular structures, called the duodenal or Brunner's glands. These duodenal or Brunner's glands exist only in this portion of the intestine.

The jejunum forms the continuation of the intestine next below the duodenum. It is so called from its being generally found in an empty condition after death. About the two upper fifths of the small intestine below the duodenum are considered to belong to the jejunum; but no definite character exists to give a line of demarcation between the jejunum and the ileum, or the portion of intestine below. In the case of jejunum and duodenum there is also an absence of any superficial mark of distinction; but Brunner's glands, it may be considered, afford the means of assigning a natural boundary line between the two.

The ileum is so named from its numerous coils or convolutions. Continuous with the jejunum above, it completes the small intestine and terminates abruptly in the large intestine below at the ileo-cæcal valve.

The large intestine in diameter considerably exceeds that of the small. Its longitudinal fibres are collected into three bands, which, being shorter than the intestine itself, give rise to the puckered or sacculated appearance it presents. It begins at the right iliac fossa in a pouch or cul-de-sac, which extends down below the entrance of the ileum, and is named the cæcum. Given off from the lower end of this pouch is a little process called the appendix cæci, or, sometimes,

from its resemblance to a worm, appendix vermiformis. A fine canal runs through the centre of this process, and opens into the cæcum. Sometimes extraneous matter becomes impacted in this canal, and sets up ulceration, which may lead to perforation, peritonitis, and death; or, through adhesive inflammation, it may become affixed to some portion or other of the abdominal parietes or contents, and leave a ring-like opening, through which a coil of intestine at some subsequent period may work down, and become strangulated and produce death. It contains a number of glands similar to those existing in the cæcum. No other function can be assigned to it than that of forming a glandular process, and it constitutes a structure that is almost peculiar to man.

Above the cæcum comes the colon. This constitutes the principal portion of the large intestine. Starting at the right iliac fossa, it describes a curve round the abdomen; first ascending on the right side, next passing across, then descending on the left side, and, finally, before ending in the rectum, presenting a double bend upon itself, after the manner of the letter S, in the left iliac fossa. From the different directions taken, ascending, transverse, descending, and sigmoid flexure portions of the colon are enumerated. The remainder of the large intestine is called the rectum. This carries the intestine through the pelvic cavity to its terminal orifice at the anus.

The sigmoid turn taken by the colon before ending in the rectum, supported as it is by the left iliac fossa, may be looked upon as forming a convenient provision for the accumulation of fæcal matter during the intervals of its evacuation from the intestine, so as to spare

the walls of the rectum and the sphincter fibres of the anus from the strain and weight that would otherwise, by an absence of the arrangement, be thrown upon them.

The ileo-cæcal valve is placed at the junction of the small with the large intestine. It is composed of a pair of semilunar-shaped folds, which project towards the cavity of the cæcum, and leave a narrow elliptical-shaped opening between them. From the position the segments of the valve occupy, a free passage is allowed from the ileum to the cæcum, or in a downward direction; but when pressure is applied on the opposite side the segments are brought into apposition, and the orifice is closed. Thus a backward course from the large into the small intestine is by the ileo-cæcal valve prevented.

The walls of the intestine are composed of the same number of coats as the stomach. Externally is an investment of serous membrane derived from the peritoneum or large serous sac of the abdomen. Next comes the muscular coat, then a layer of areolar tissue constituting the submucous coat, and afterwards the mucous coat by which the free internal surface is formed. The muscular and mucous coats will each require some words of special reference to be made concerning them.

The muscular fibres are, like those of the stomach, of the simple or non-striated kind. They are arranged in two layers, the inner layer consisting of circular, the outer of longitudinal fibres. By these two sets of fibres the peristaltic movement, as it is called, which the intestine undergoes is produced. Successive waves of contraction, followed by relaxation, pass along the

canal, and occasion an undulatory or vermicular kind of movement. Thus the alimentary matter is urged onwards over the intestinal surface, absorption of its nutrient portion taking place, and the excrementitious residue being conveyed to the lower extremity of the alimentary canal, ready for expulsion from the system whenever it may be desired.

The movement observed in the intestine when the abdomen of an animal is opened immediately after death, is by no means to be taken as a correct representation of that which is naturally occurring during life. The idea given on watching the exposed intestine in a recently killed animal is that the coils in their movement resemble a bundle of worms actively writhing in and out. What is here seen, however, forms a highly exaggerated representation of the movement that naturally occurs; and in it, also, there is a want of regularity and of any show of design. In the action that takes place during life there is a definite, slow, rhythmic movement, which gradually propels the intestinal contents downwards through the canal. By an increased activity of movement, such as may be brought about by the presence of irritating matter in contact with the mucous surface; and, in some dispositions, by the influence of a mental shock or impression, the intestinal contents may be urged too rapidly along the canal, and diarrhœa thereby produced.

It has been suggested that the contact of air is the cause of the exalted movement of the intestine which is seen when the abdomen is opened immediately after death. This, however, cannot form the true explanation, because it may be noticed without exposure to the air being made. If the belly of a rabbit, for instance,

be watched whilst the animal is alive, the movement of the intestine is not to be, or scarcely to be, perceived. Let it be watched, however, immediately after death, and a vigorous movement is to be recognised through the abdominal walls without any opening into the abdominal cavity having been made. Exposure of the intestine also, during life, does not excite that exalted peristalsis which is observable after death.

Schiff asserts that the exalted action is due to the influence of the stoppage of the flow of blood on the muscular fibres. He says, as active intestinal contractions may be induced by compressing the abdominal aorta during life as what occur after death; and that on removal of the compression the excited action disappears. Bernard states that the excited peristalsis, taking place as the result of death, may be subdued by re-establishing the circulation by the performance of artificial respiration, and that its re-appearance is noticed when the artificial respiration is stopped. This is in harmony with Schiff's assertion; but it is to be remarked that other circumstances besides the stoppage of the circulation are capable of inducing the phenomenon, for Bernard has noticed it after division of the spinal cord between the origin of the cervical and brachial plexuses; and I have witnessed its production by the injection of carbonate of soda into the circulatory system.

When an obstruction exists in any part of the small intestine, a backward flow of its contents takes place towards the stomach; and what is called fæcal vomiting is induced. It is only the contents of the small intestine that can be thus returned into the stomach

and ejected by the mouth, as the ileo-cæcal valve would offer a complete barrier to a backward flow from the large intestine into the small.

The backward flow which occurs with fæcal vomiting was formerly put down as attributable to an inverted action of the muscular fibres of the intestine—an anti-peristalsis; but Dr. Brinton has shown that another explanation, and one which does not involve any inverted muscular action, can be given. Peristalsis, he says, in an obstructed tube distended with fluid, produces a double current—a forward movement at the periphery, and a backward one in the centre or axis of the canal. The muscular fibres, acting in a downward direction, and with a force proportionate to the resistance that is to be overcome, propel the intestinal contents to the seat of obstruction, whence they must take the course that offers the least amount of impediment to their progress. This is a backward one along the centre or axis of the canal, or the position most remote from that at which the downward propelling influence of the intestinal muscular fibres is exerted upon the contents of the canal. Thus, by the ordinary downward peristaltic action the reflux of matters from the seat of obstruction in a strangulated intestine through the part above into the stomach can be accounted for. Their subsequent ejection from the stomach completes the train of phenomena concerned in fæcal vomiting.

The muscular fibres of the intestine are all of the plain or non-striated kind. Their nervous supply is derived from the sympathetic system, and in their action, therefore, they are not under the obedience of the will. At the lower extremity of the canal fibres

of the striated kind are provided to govern the outlet. These are supplied from the cerebro-spinal system, and placed under the controlling influence of the will.

The mucous coat of the intestine presents characteristic peculiarities in different portions of the canal. In elementary constitution it resembles other mucous membranes. Its epithelium, like that of the stomach, is of the columnar variety. A layer of smooth or unstriped muscular fibres has been described by Brücke as existing in its deeper part. These muscular fibres of the mucous membrane are quite independent of those which have been described as forming the muscular coat. In man their slight development renders it often very difficult to discover them; but in animals where they are well developed, two sets, longitudinal and transverse, are stated to have been found.

The structures belonging to the mucous coat calling for examination are certain projections—valvulæ conniventes and villi; and glands of various kinds, viz. Brunner's glands, follicles of Lieberkühn, solitary glands, and Peyer's patches.

The valvulæ conniventes consist of closely packed, transverse, crescentic-shaped folds of mucous membrane, projecting into the cavity of the canal. Unlike the folds of mucous membrane met with in the stomach and œsophagus, these are permanent inflections: no distension to which the intestine can be subjected leading to their obliteration. They belong only to the small intestine, and are not encountered throughout the whole length of this. Beginning about an inch, or rather more, below the pylorus, they extend through the remainder of the duodenum, the jejunum, and about the upper half of the ileum. They attain their

largest dimensions in the duodenum and jejunum. In the ileum they gradually diminish in size, as it is traced down, until about the middle of it, when they entirely disappear. The largest measure from a quarter to half an inch in breadth across the centre, which is their widest part, and in length they may nearly encircle the bowel.

Floating in the intestinal canal, and bathed by its contents, the valvulæ conniventes will have the effect of materially increasing the extent of surface for the absorption of nutrient matter. At the same time, projecting into the canal, as they do, they will, to a certain extent, delay the alimentary matters in contact with the absorbing surface, and so tend to render the process of absorption more complete. These valvulæ conniventes are said to be peculiar to the human subject.

The villi constitute important absorbing organs. They consist of minute projecting processes, so thickly studding the mucous surface as to give to it, where they exist, a velvety appearance. They are structures that belong only to the small intestine. Beginning at the upper part of the duodenum, they extend down over the whole surface of the small intestine, clothing the valvulæ conniventes in their course, and come to an abrupt termination at the free edge of the ileo-cæcal valve. Thus, the surface of the valve directed towards the ileum is covered with, whilst that directed towards the cæcum is devoid of, villi.

Much variety exists in the shape and size of the villi of different animals. Considerable variation is also observable in the different villi, as they are seen upon the intestine of the human subject; but their usual form may be said to consist of more or less flat-

tened cones. They are of sufficient size to be visible to the naked eye, and are best viewed by placing the mucous membrane under water, when they float and stand apart from each other.

The villi constitute little solid processes formed out of the elements of the mucous membrane. Each consists of a central portion or basis covered with an investing layer of epithelium. In the substance of the villus there are found blood-vessels, a branch of the lacteal system, and some unstriped muscular element, lying in a stroma or basis of fibrous material, and surrounded by basement membrane, which supports the investing epithelial layer. Nerves have not as yet been recognised in the villi.

The blood-vessels of the villi are exceedingly numerous. Small arteries pass up into the process, and terminate in a close network of capillaries placed immediately beneath the basement membrane. After traversing the capillaries, the blood is returned from the villus usually by a single vein, which forms one of the tributary sources of the portal system. By means of these blood-vessels substances of a soluble and diffusible nature are taken up from the intestine and carried to the liver. Their great vascularity renders the villi exceedingly beautiful microscopic objects in injected preparations.

A branch of the lacteal system for conveying away the product of special absorption, passes through the centre of the villus and escapes at its base. In what way it commences at the free extremity of the villus, has not as yet been satisfactorily made out. During intestinal digestion the villi are charged with chyle, and thereby rendered opaquely white. They now give a

dense white character to the mucous surface, which it does not present at other times.

The muscular element was first recognised in the villi by Brücke. It consists of a thin layer of longitudinal fibres arranged immediately around the central lacteal. It is, no doubt, derived from that general expanse of unstriped muscular tissue which has been somewhat recently found to pervade the whole mucous membrane of the alimentary canal. The corrugation of the villi and the retraction of their substance from their epithelial covering—appearances to be observed on examining the intestine immediately after death—form conditions produced by the contraction of this tissue. It is asserted that contractions have been witnessed in the villi during life, and it has been suggested that such contractions functionally take place, and fulfil the purpose of forcing on the chyle through the lacteal of the villus.

The matrix of the villi consists of indistinctly marked fibrous tissue. Although presenting but obscurely marked structural characters, Kölliker says it must undoubtedly be regarded as a metamorphosed connective tissue, without any admixture of elastic element.

The basement membrane forms a layer of perfectly homogeneous material which surrounds the structures that have been already described. It supports the epithelial investment, and is continuous with the same structure belonging to the general mucous surface of the intestinal tract.

The epithelial investment of the villus is composed of a single layer of columnar or club-shaped particles, which rest with their pointed extremities downwards

upon the basement membrane. Their other extremities, which are flat, form the free surface of the villus, and being evenly packed together give rise to the production of a pavement-like appearance. Each cell is provided with an oval-shaped nucleus.

It was formerly stated by Goodsir that the villi became deprived of their epithelial investment at the commencement of intestinal digestion, and remained in that state till the process of digestion was completed. He considered that by this shedding of its epithelium, through which the villus would lie naked amongst the intestinal contents, a more favorable condition was presented for the process of absorption. Digestion being at an end, and absorption no longer going on, the villus was said to again acquire its protective coating of epithelial particles.

It is not difficult to show that this representation of Goodsir is erroneous, and to point out the fallacious ground upon which it was founded. The absorbing as well as the non-absorbing villus is in reality covered with epithelium, as may be seen by conducting the examination *immediately* after death. If, however, whilst digestion is being carried on, a short period only be allowed to elapse after death, before the examination is made, the villi will be found in a more or less denuded state. Within an astonishingly short space of time, indeed, the epithelium begins to fall away after death, and leave the basement membrane of the villus exposed. At first, the epithelial particles adhere together in clustered masses as they are shed, but ultimately they all fall apart, and then the examination displays a naked villus lying in an epithelial débris, or mass of isolated epithelial particles. It seems as

though the juices present in the intestine at a period of digestion possessed the power of acting on the epithelial layer immediately after the extinction of life, so as to bring about the disintegration noticed.

According to the observations I have conducted, the epithelium is not in the same way rapidly thrown off when death has taken place at a period of fasting, but may be found attached many hours afterwards. Thus, the statement of Goodsir can be reconciled, and an illustration is afforded of how necessary it is in forming conclusions about conditions belonging to life from what is observed after death, to guard against being misled by the results of post-mortem change.

Instead of the epithelial investment of the villus being shed during absorption, it seems, indeed, to constitute the agency by which its special absorbing function is exerted. It appears, for instance, to be the epithelial cells covering the villus that pick out the constituents of the chyle from the intestinal contents. For this, the cells must be endowed with the power of drawing within them certain materials from the alimentary matter around and rejecting others, just as the secreting cells of glands are found to select from the various constituents of the blood the appropriate elements for the formation of the different secretions. Whilst absorption is going on, the epithelial cells are to be seen charged with fat-particles, which they have evidently drawn from the intestinal contents. These they, in some manner or other, not as yet satisfactorily made out, discharge into the central lacteal of the villus, to form the fatty element of the chyle. During the process of absorption many of the cells are observed to assume more or less of a spheroidal form. Cells, however, presenting their or-

dinary columnar shape, are also to be seen charged with fat, and must therefore be looked upon as likewise taking part in the absorbing process.

Looking now to the glandular structures of the intestine, what are called Brunner's glands are the first to which I will direct attention. These belong to the upper part of the intestine or duodenum; hence the name "duodenal glands," by which they are also known. They are open glands, and in their minute anatomy exactly correspond with the pancreas. There is only this difference, indeed, between the pancreas and Brunner's glands—the former consists of lobules aggregated together into a circumscribed mass around a common duct; whilst the latter consist of lobules spread out in an isolated manner, beneath an extended surface, each little glandular mass being provided with an independent duct, through which the secretion is discharged into the alimentary canal. The extent of these glands may be looked upon as affording a means of anatomically defining the limits of the duodenum. They also give to it a physiological character of distinction from the remainder of the small intestine. Near the pylorus, where they are most numerous, they are so closely clustered together as to form a compact glandular layer in the submucous tissue, and are here from one eighth to one tenth of an inch in diameter. Followed downwards through the duodenum, they become smaller, and more and more scattered, until they cease altogether. The little duct with which each glandular mass is provided dips through the mucous membrane from the surface, and, after branching repeatedly, terminates in vesicular dilatations, which are lined with the secreting cells. Brunner's glands are found to be

more highly developed in the herbivorous than in the carnivorous animal.

The secretion of Brunner's glands, on account of their anatomical disposition, cannot be obtained in a pure or unmixed form. Nothing, therefore, can be said regarding its properties beyond that it is a colourless and apparently a viscid and alkaline fluid. For the same reason its physiological action cannot with certainty be mentioned, but it probably agrees with the secretion of the pancreas in the functions it discharges.

Lieberkühn's follicles exist throughout the whole length of both the small and large intestine. They consist of small, simple, straight tubules, thickly set in the mucous membrane perpendicularly to its surface. Each tubule is open above and terminates below in a closed rounded extremity; or, occasionally, it appears to bifurcate into two. In length they correspond to the thickness of the mucous membrane. They are lined with a layer of epithelial cells similar to those investing the villi, and therefore of the cylindrical or columnar shaped variety.

Closely packed together as they are, and extending throughout the whole length of the intestine as they do, an infinite number of these tubules exist. Looked at singly they appear insignificant, but viewed collectively it is evident that they must constitute an important apparatus. Their secretion cannot be collected in an unmixed form, and nothing can be definitely stated with regard to its amount. Thus much, however, may be said respecting its properties, namely, that it constitutes a clear, colourless, and strongly alkaline fluid, endowed with the power of actively transforming starch into

sugar. It forms the chief constituent of what is called "intestinal juice."

The solitary glands consist of closed sacs having a flask-shaped form, with the pointed extremity directed upwards. They lie imbedded in the mucous membrane, and when in a state of repletion are of about the size of a mustard seed. They may then be readily seen by holding the intestine up towards the light, but in an empty state they are not easily discoverable. Their contents, consisting of a soft, pulpy, semitransparent, greyish-coloured material, must be looked upon as constituting a product of secretion. The elementary constituents of this material displayed by the microscope consist of nuclei, cells, and granular matter.

The solitary glands are found scattered here and there along the whole length of the intestine, including its small and large divisions. They exist in large number in the appendix of the cæcum, and are more numerous in the large than in the small intestine. Their number, however, is very various in different individuals, sometimes not a single one being discoverable throughout the whole small intestine, whilst at other times they are found there in considerable quantity. The mucous surface, with its projecting villi, is traceable over them in an uninterrupted manner in the small intestine. In the large, the glands are of greater size, and upon each of the little prominences upon the surface created by their presence there is a small aperture which leads to a little pit or depression in the mucous membrane. The existence of these depressions formerly led to the notion that the solitary glands of the large intestine differed from those of the small (over which no such depressions ordinarily exist)

in being provided with an opening communicating with the surface. The appearance of an opening, however, is fallacious, for at the bottom of the depression the follicle is to be found in a closed condition like that existing in the small intestine.

Peyer's patches are simply collections of solitary glands clustered together into circular, oval, or oblong shaped patches. They are met with only in the small intestine, and are invariably situated on that part of the intestine which is most remote from its mesenteric attachment. Upon an average, about twenty of these patches are found to exist. They increase in size as they are traced downwards, and in the lower part of the ileum may measure in their long diameter, which runs lengthways in the intestine, as much as from two to four inches, whilst in the jejunum their greatest measurement may not be more than half an inch. These patches are not only, as has just been mentioned, larger, but are also more numerous, in the ileum than elsewhere; indeed, it is to this part of the intestine that they may be considered particularly to belong. The number of solitary glands in a patch may vary from 20 or 30 to 100 or 200, according to its extent. Peyer's patches are more developed in carnivorous than in herbivorous animals.

Little can be said about the function of the closed follicles of which the solitary glands and Peyer's patches are formed. What they contain must be regarded as a product of secretion; but whether this is destined for return into the system by re-absorption, or for discharge into the intestine by rupture, has constituted a matter of dispute. Being larger during digestion than fasting, the former may be considered to

constitute their period of greatest functional activity. There are grounds for regarding the material which gives the characteristic odour to the fæces as a product of elimination from the system by these glands. In typhoid fever they are found to be specifically affected, and thus arises the ulceration of the intestine that forms so frequent an accompaniment of this disease. In phthisis also they are prone to become the seat of tubercular deposit; and this deposit, leading to ulceration, accounts for the colliquative diarrhœa from which phthisical patients so often suffer in the latter stage of the complaint.

The mixed secretion from the glandular structures of the mucous membrane of the intestine constitutes what is called "intestinal juice." Frerichs procured the intestinal juice by placing a couple of ligatures on a coil of intestine at a period of fasting, and, from four to six hours afterwards, collecting what had accumulated between them. Bidder and Schmidt prevented the flow of bile and pancreatic juice into the alimentary canal, and established a fistulous opening in the small intestine, about one third of its distance down. They afterwards collected the secretion that escaped from the intestine through the fistulous opening that had been made. It cannot be considered that by either of these processes a perfectly natural intestinal juice has been procured. Thus much, however, may probably be stated as regards its properties, viz. that it constitutes a colourless, viscid, alkaline fluid, endowed with the power of converting starch into sugar and of emulsifying fatty matter.

Experiment seems to show that the intestinal juice is also capable of exerting a solvent influence upon nitrogenized substances. Bidder and Schmidt found

that meat and coagulated albumen placed in a muslin bag, and introduced into the small intestine whilst in an empty state, and with a ligature applied above to prevent the descent of bile and pancreatic juice, gave evidence in four to six hours' time of a considerable amount of digestive action having occurred. In an experiment performed by myself, the hind legs of a frog, which had been similarly introduced into the intestine, were found, at the end of six hours' time, in a partial state of digestion: a portion of the skin, for instance, having been dissolved away, the muscles underneath separated, and some of the bones to a slight extent exposed.

Little is known about the secretion of the large intestine beyond that it presents, like that of the small, an alkaline reaction. The secretion of the cæcum forms no exception to this, although from what is observed in some animals a contrary conclusion might be arrived at. The strongly acid reaction, however, often found to be presented by the contents of the cæcum does not depend upon an acid secretion being poured out, but upon the changes that occur amongst the contents themselves.

To complete the examination of the agents concerned in intestinal digestion, two important glands remain to be referred to—the pancreas and the liver.

The pancreas—or sweetbread, as it is popularly styled—is a gland that presents an elongated flattened form. It stretches across from one side of the upper part of the abdomen to the other, close in front of the spinal column. The left extremity is pointed, and constitutes what is called by anatomists the tail of the gland. At the other extremity an enlargement exists, which is embraced by the curvature of the duodenum.

This is called the head. Altogether, the gland presents a somewhat hammer-like form.

In appearance, the glandular tissue of the pancreas resembles that of the salivary glands, and there is also a corresponding resemblance in their minute anatomy. It is conspicuously lobulated upon its exterior, and also throughout its substance. It is unprovided with any distinct capsular investment, but surrounded by areolar tissue, which dips down between and connects the lobules. Its duct—the canal of Wirsung—courses through it from left to right, in a central position, gradually increasing in size as tributary branches join it on its way. After escaping from the gland it arrives in contiguity with the bile-duct, the two afterwards passing obliquely through the coats of the duodenum to terminate in a joint opening upon the summit of a little papillary elevation observable upon the mucous surface about three or four inches below the pylorus. Usually, it would seem, a second duct springing from the head of the gland opens into the duodenum a little lower down. Sometimes this throws itself instead into the principal canal; but since attention has been directed to the point by the dissections of Bernard, it has been found that the former condition prevails so frequently as to constitute the ordinary instead of, as formerly considered, the exceptional state.

In ultimate elementary structure the pancreas exactly resembles the salivary glands. The lobules of which the organ is made up form but repetitions the one of another. The lobular ducts join together, and these, again coalescing, ultimately form the principal duct of the gland. Reversing the description, and tracing these ducts in the opposite direction, after dividing and

subdividing until they have become reduced to exceedingly small dimensions, they are found to terminate in clusters of vesicular dilations consisting of basement membrane lined with secretory epithelium. Around these vesicular terminations of the duct, capillary blood-vessels are arranged in a plexiform manner, and afford the supply from which the elements of secretion are drawn.

The secretion of the pancreas, or pancreatic juice, has been collected from various animals direct from the duct; and thus, precise language can be employed regarding its characters, properties, and use. It is only temporarily, however—only for two or three days after the operation that is required to be made has been performed—that the secretion can be obtained, on account of the canula introduced into the duct setting up ulcerative action, which causes it to loosen and come away. Then, in the course of a short time, through nature's efforts, the duct becomes re-formed, and the flow of secretion takes place into the intestine as before. It is to Bernard's investigations that we are indebted for most of the knowledge we possess regarding the physiological attributes of the pancreatic juice. My own experimental experience, however, enables me to testify to the accuracy of what is about to be stated upon the subject.

As with the saliva and gastric juice, it is only when its presence is required that the pancreatic juice flows into the intestine. At a period of fasting no discharge of secretion takes place from the gland. Shortly after food has been ingested, however, pancreatic juice begins to flow, and continues to escape as long as the process of digestion is being carried on.

Pancreatic juice, when in a normal state, constitutes a transparent, colourless, odourless, and viscid liquid, with a slightly saline taste and a decidedly alkaline reaction. Exposed to heat, it coagulates to a solid consistence, from the large quantity of a kind of albuminoid matter it contains. As with albumen, a coagulation is also formed by alcohol and the mineral acids. Although thus closely allied to albumen, still the coagulable principle of the pancreatic juice is not strictly identical with it, for it forms the active constituent of the secretion, and so possesses properties which albumen does not.

The pancreatic juice which is first collected, when the operation is performed shortly after the ingestion of food, and has turned out satisfactorily, is viscid, and richly charged with the above-mentioned coagulable principle. That which flows later is poorer, or more watery; and finally, before the canula introduced into the duct comes away, a fluid may escape no longer enjoying the power belonging to the normal secretion. With this deterioration in the quality of the secretion the alkaline reaction becomes more intense, and the addition of an acid now determines a marked effervescence from the amount of alkaline carbonate present.

Pancreatine is the name given to the albuminoid material which endows the pancreatic juice with the physiological properties it enjoys. This material was formerly confounded with albumen, but there is a chemical as well as a physiological difference between the two; for after having been precipitated by alcohol, pancreatine is redissolved by water, and a fluid possessing the power enjoyed by the pancreatic juice is obtained.

It was discovered by Tiedemann and Gmelin that

the pancreatic juice is reddened by an aqueous solution of chlorine, and Bernard has shown that this effect is due to the presence of pancreatine. It is not with the perfectly fresh juice that the solution of chlorine reacts, but only after a change has taken place by keeping. When decomposition, however, is advanced, chlorine is found no longer efficacious in developing the colour, but now nitric acid will produce it instead.

A watery infusion of the substance of the pancreas behaves in this respect in the same way as the secretion. Neither bile, nor saliva, nor gastric juice amongst the digestive liquids gives rise to this reaction; but, according to Bernard, the liver, spleen, and lymphatic glands, yield infusions which, like that of the pancreas, are reddened by chlorine.

Nothing, I am of opinion, can be definitely said about the quantity of pancreatic juice normally secreted, for it can scarcely be conceived that the action of the gland can escape being prejudicially influenced by the operation to which the animal has necessarily to be subjected for the process of collection.

In speaking of the physiological action of the pancreatic juice, there are three points of view under which it will have to be looked at: these are, the action it has the power of exerting upon—

1. Starch,
2. Fat, and
3. Albuminous materials.

The pancreatic juice possesses the power of rapidly transforming starch into sugar, and physiologists are all of accord in assigning to it this as one of its functions. Starch must be transformed before it can be of service to the animal being. Remaining as starch, it

would simply pass through the alimentary canal, and thus prove a useless material to the system, because it altogether resists absorption. The saliva, in the case of the human subject, certainly also possesses the power of rapidly converting starch into sugar; but, as pointed out under the head of that secretion, the conditions under which it is placed are so unfavorable for the exercise of the endowment in question that it cannot be possible for much action to occur. With the pancreatic juice, however, the surrounding circumstances are all in the highest degree favorable for the exercise of its transformative influence. The food, for example, has been reduced to a semi-liquid state before reaching the duodenum, where its admixture with the pancreatic juice takes place. The two then are urged slowly along the intestinal canal by the peristaltic movement that occurs, and thus cannot fail to become thoroughly incorporated together. Brought and delayed in this manner in contact with each other, and also exposed to the elevated and equable temperature existing in the interior of the body, the most favorable circumstances are offered for the occurrence of metamorphosis. As the transformation is effected the sugar produced is absorbed by the blood-vessels and carried to the liver, where a further change of an assimilative nature is effected.

The next office of the pancreative juice to be spoken of is that connected with the digestion of fat. Eberle, it appears, was the first to announce, which he did as far back as 1834, that the pancreas possessed the power of emulsifying fat. He experimented, however, only with the glandular tissue of the organ, and never obtained its secretion. His announcement also could not

have received much attention, as it is not until after the publication, in 1848, of Bernard's extensive series of experiments, commenced in 1846, that the pancreas is found to be spoken of by physiologists in connection with the digestion of fat. Before Bernard's researches nothing was known about the nature of the pancreatic secretion, and nothing had been shown to connect it with the digestion of fat. Bernard is therefore fairly entitled to the credit of discovering the function of the pancreas now about to be referred to.

It appears that Bernard was led to the prosecution of his researches upon this subject through observing, whilst conducting some experiments for the purpose of comparing the phenomena of digestion in the animal and vegetable feeder, that after the ingestion of fat the lacteals coming from the intestine almost up to the pylorus were found to be injected with milky chyle in the dog, whilst in the rabbit chyle only made its appearance in the lacteals some little distance down. With this, he noticed a corresponding difference in the point of discharge of pancreatic juice into the intestine, and thus was prompted, whilst seeking for an explanation of the phenomenon, to give attention to the pancreas. In this manner he was led to endeavour to collect the pancreatic juice, and, having succeeded in this, to examine its action upon fat.

The effect produced when pancreatic juice is freely shaken with oil or fat is to form a liquid having the appearance of milk. The pancreatic juice emulsifies or brings the fatty body into a minutely divided state; in which, it afterwards remains suspended in the liquid in the same manner as is noticed in milk. The minute globules into which the fat has been separated have no

disposition again to coalesce and rise and form an oily layer at the surface, as they do when saliva or any ordinary watery liquid may happen to have been used instead. In this state of minute subdivision the fatty matter is found to be adapted for absorption and passage into the lacteals, the effect of its presence in the lacteals being to give to their contents a milky character, which they do not possess when no absorption of fat is going on.

So far, the action of the pancreatic juice on fatty matter is only one of a physical kind; but if the emulsion be placed aside for a few hours a chemical change will be found also to have taken place. When the admixture of a neutral fat and pancreatic juice is first of all made, the resultant liquid is alkaline, owing to the alkaline character which the pancreatic juice enjoys. In the course of a few hours, however, a decidedly acid reaction is found to exist, and this arises from the decomposition which the fatty matter undergoes. The neutral fats are chemically acted upon by the pancreatine, and resolved by it into their constituent acid and glycerine. The liberation of the fatty acid thus accounts for the acid behaviour which the emulsion, as above mentioned, in the course of time acquires.

It is only with pancreatic juice of good quality that this acidification of the neutral fats is found to be brought about. The tissue of the pancreas behaves in the same manner as the secretion, but it requires to be fresh. According to Bernard, the power of acidifying neutral fats characterises pancreatine from all other products of secretion, and it has been suggested by him as furnishing a means of recognising the pancreas in members of the animal series where a doubtful condition exists.

Although the pancreatic juice is endowed with this chemical power, yet such, it is to be observed, is not exercised under physiological circumstances. The emulsifying action is immediate, but the chemical change requires time to be allowed for its production, and the emulsified fat is not long delayed in the intestine before its absorption is effected. As a conclusive argument upon the subject, it has been found that the fatty matter reaches the chyle without presenting evidence of having undergone any chemical alteration.

The negative evidence derivable from the suppression of the influence of the pancreas is confirmatory of its possessing a digestive power over fat. Dr. Bright, as far back as 1832, related cases at the Medico-Chirurgical Society, in which he had noticed the voidance of large quantities of fatty matter with the alvine evacuations in connection with malignant disease of the head of the pancreas and ulceration of the duodenum. Dr. Bright, however, stated that he did not affect to decide whence the peculiar fatty matter was derived—whether it was thrown out from the diseased parts or whether it formed a product of defective digestion. Bernard's researches have since supplied the explanation, and it has been found that, on experimentally destroying the secreting power of the pancreas, which can be done by forcibly injecting oil through the duct into the tissue of the gland, fat is voided with the dejections when fatty matter is given with the food.

A further function, that of acting as a supplementary organ to the stomach in the digestion of azotized materials has also been assigned to the pancreas. Purkinje and Pappenheim, in 1836, asserted that the pancreas contained a principle capable of exerting a digestive

action upon the azotized elements of food. This assertion, however, did not lead to any further result, and the matter was suffered to drop until its recent revival by Corvisart, of Paris, who now strenuously maintains that the pancreas, in addition to its other functions, acts as a supplementary organ to the stomach, and digests, after a copious meal, the nitrogenized alimentary materials that happen to have escaped being digested in that viscus. He states that the nature of the two digestions—gastric and pancreatic—is alike as far as the result is concerned, each leading to the production of albuminose. Whilst, however, the existence of acidity forms a necessary condition for the exercise of digestive power in the case of the gastric juice, the secretion of the pancreas, he affirms, enjoys the privilege of acting equally well whatever the reaction that may exist—no matter, in other words, whether it may chance to be in an acid, a neutral, or an alkaline state.

Three sets of experiments are brought forward by Corvisart in support of his affirmation.

First, he says, that if the pancreas of an animal be taken when its active principle is at its maximum in quantity and quality—that is, from the fourth to the seventh hour after the commencement of digestion—and be immediately finely cut up, and infused for an hour with twice its volume of water at a temperature of 20° Cent. (68° Fah.), and the infusion be at once experimented with, it will be found to possess the power of dissolving the nitrogenized alimentary principles and converting them into albuminose; and this, without any evidence of ordinary putrefaction being perceptible, if the experiment be stopped at the end of four or five hours, in which time, under exposure to a temperature of about

100° (Fah.), the pancreatic principle will have accomplished all that it is capable of effecting.

Secondly, that the pancreatic juice obtained from the duct of the gland during life is found to be capable of exerting likewise a powerful solvent action upon the nitrogenized alimentary principles when the proper rules are observed in conducting the experiment. To exhibit the digestive power in question, the operation, he says, must be performed four hours after the ingestion of food, and the juice be experimented with that flows during the following three hours, the period at which it is charged to its maximum extent with the pancreatic principle. It must also be experimented with immediately after its collection. Pancreatic juice, according to Corvisart, dissolves fibrine more rapidly and largely than albumen. The heat being maintained between 42° and 45° Cent. (108° and 113° Fah.), a specimen of pancreatic juice of ordinary energy dissolves, he says, if agitated with the aliment submitted to its action every quarter of an hour, all that it is capable of dissolving of fibrine in two or three hours at the most, and of solid albumen in four or five hours: the experiment up to this period being unattended with any evidence of ordinary decomposition; whilst, subsequently, ordinary decomposition is found to set in.

Thirdly, that azotized substances introduced into the duodenum at a period when pancreatic juice is flowing into it are found to be dissolved, notwithstanding that the gastric juice and bile are shut off, by ligaturing the pylorus and bile-duct.

I was formerly of opinion that in the effects produced upon azotized matter by the pancreatic juice we had to deal with changes of the character of putrefaction

rather than true digestion. I must confess, however, that, although putrefaction very readily and rapidly sets in, I am now inclined to believe, upon the evidence of more recent experiments, that some amount of action may be exerted which cannot be ascribed to putrefaction. I have carefully followed the rules laid down by Corvisart; and although in some of my experiments the results have not been free from signs of accompanying putrefaction, yet I have observed, what I presume must be considered, digestive action without it.

The pancreas of the dog, for instance, has been taken at periods varying from four and a half to seven hours after the ingestion of food, and immediately either chopped up finely or bruised in a mortar, and infused for from half an hour to an hour in from three to six ounces of water. Frogs' legs have been used as the test, as in my experiments upon gastric digestion, and the temperature employed has ranged between 105° and 115° Fah. Upon some occasions in about four hours' time the legs, although appearing externally intact, were acted upon in such a manner that the soft parts easily broke down under very slight pressure—and this, without any smell of decomposition being apparent. Upon other occasions, and in the same period of time, a more or less strong smell of decomposition has been present. Where the action has been allowed to continue longer, an extensive disintegration of soft parts has been observed, but the product has smelt most strongly of decomposition. The bones have not been found to suffer attack as they do with gastric juice.

It is true, a strongly solvent action is exerted upon animal matter in the interior of the duodenum. With the pylorus and also the bile-duct ligatured, and the

frog's legs introduced into the duodenum, I have found in a few hours' time that the soft parts have been dissolved so as to leave the bones in a perfectly clean state behind. In such an experiment it must be borne in mind that there is intestinal as well as pancreatic juice to act. And, that the former can exert some effect may be looked upon as shown by the result obtained in another experiment, where, a ligature being applied around the duodenum below the pancreatic duct, and the frog's legs introduced below this, a considerable amount of digestive action was still observed to occur.

The liver forms by far the largest of all the glandular organs of the body, and is the most universal in its presence throughout the animal series. There are few animal beings, indeed, that are possessed of a digestive cavity, where some form of biliary apparatus cannot be discovered. The power of secreting bile exists before any distinct organ is found to be developed for the purpose. Thus, in some of the lower animals, where nothing in the shape of a distinct liver is present, cells are to be seen lodged in the walls of the digestive cavity, which, from the colour of their contents, are judged to be of a biliary nature, or, in other words, to perform a bile-secreting office.

The average weight of the liver in the adult human subject is from three to four pounds. It is placed in the upper part of the abdominal cavity, and concealed under and protected by the ribs of the right side. It is uniform in appearance, smooth upon its surface, and of a dark reddish-brown colour. Its upper surface is rounded, adapting it to the concave under surface of the diaphragm, with which it lies in contact. Its under surface is flattened and marked by certain fissures

which map it out into portions called by anatomists its lobes. To this under surface is attached the gall-bladder, a temporary receptacle for the bile. Its posterior border is rounded or obtuse, and fixed to the abdominal walls by reflexions of serous membrane passing from its upper and under surfaces. Its anterior border is sharp and free, and corresponds with the lower margin of the chest. A thin capsule of fibrous tissue is found to invest it, and over this is the serous layer derived from the peritoneum, which gives to the organ the shiny or glistening surface it presents. The reflexions of peritoneal membrane connecting the liver with surrounding parts serve to suspend and keep it in position, and are anatomically spoken of as ligaments.

The liver is an exceedingly vascular organ, the blood that passes through it being derived from two sources, an arterial and a venous. The arterial blood must be looked upon as specially intended for contributing to the maintenance, or nutrition of the organ; the venous blood, on the other hand, which consists of the blood which is being returned from the stomach, intestines, pancreas, and spleen, is designed for administering to its functional operations. The first-named blood reaches the liver through the hepatic artery, the latter through the portal vein. The blood from both these sources traverses the capillaries of the organ, and, reaching the hepatic vein, is thereby conducted into the inferior cava, and thence to the right side of the heart.

On looking closely into the texture of the liver, it is seen to be made up of a multitude of small, closely packed, tolerably equal-sized masses, which constitute the hepatic lobules. These lobules form an exact repetition the one of another, and each may be looked

upon as representing, as it were, an elementary liver, the entire organ being simply, in fact, composed of a collection of these primary components.

The lobule consists of blood-vessels lying in close relation with cells—the hepatic cells, which form the secreting element. Blood reaches the circumference of the lobule through the branches of the portal vein. Capillary vessels are derived from these, which converge to the lobular centre, and there terminate in a radicle of the hepatic vein. The blood also which traverses the hepatic artery finds its way into the converging capillary plexus of the lobule, and so reaches the hepatic vein, the vessel by which it is returned from the liver into the general circulation.

The substance of the lobule is in great part composed of the hepatic cells, which are therefore exceedingly numerous. They lie closely interwoven with the capillary blood-vessels; and thus, the blood and the secreting element of the liver are brought into the closest relation with each other. The cells consist of nucleated particles, varying in size from the 1000th to the 2000th of an inch in diameter. In form they are more or less spheroidal—or, often, polyhedral from mutual compression. Fat-globules and pigment-granules are usually to be seen in them as well as the nucleus.

The manner in which the secreting cells of the lobules are connected with the hepatic duct has formed a much debated point amongst anatomists. Kiernan was of opinion that the hepatic duct commenced as a plexus in the lobule, which he styled the lobular or secreting biliary plexus. He had never succeeded in fully displaying this plexus; but, from the ramifications of the ducts between the lobules, he had seen branches

passing into them and forming a plexus at their circumference. Dr. Beale asserts that he has succeeded in demonstrating the existence of very delicate tubular processes of basement membrane extending into the lobules from the hepatic ducts, and enclosing the hepatic cells. The arrangement which Kiernan conjectured to exist Dr. Beale believes he has succeeded, by injection and otherwise, in displaying. A lobule, he says, is composed of a network of capillary blood-vessels intertwined in the closest manner possible with a network of exceedingly delicate tubules which form extensions of the hepatic duct and enclose the hepatic cells. This he calls the cell-containing network of the lobule, and, from the relation it holds to the blood-vessels, the secreting element of the liver is brought into the closest intimacy with its vascular supply. Usually, Dr. Beale says, there is room for only one row of cells in the tubules, though in some portions of the network two and three rows have been found. The cells lie unattached in the tubules.

The minute branches of the hepatic duct emerging from the lobules unite with each other, and the process of coalescence is continued until ultimately the single duct that escapes from the under surface of the liver is formed. This—the hepatic duct, after coursing for a short distance downwards towards the duodenum, is joined by a canal—the cystic duct, which connects it with the gall-bladder. Below this point, the duct which conveys to the duodenum both the bile that has passed into the gall-bladder and that which is descending direct from the liver is known by the name of *ductus communis choledochus*. Before its termination the *ductus communis choledochus* arrives in contiguity with the pan-

creatic duct. The two then run side by side, and ultimately open into the duodenum together, upon the summit of a papilla about three or four inches below the pylorus.

The gall-bladder constitutes a diverticulum or receptacle connected with the hepatic duct, intended for the temporary retention of bile, when its flow into the intestine is not required. It forms a pear-shaped bag, capable of holding rather more than an ounce. Considerable diversity, it is to be mentioned, is found to exist as regards its presence amongst the different members of the animal kingdom. It is not present in any of the invertebrata. It is usually met with in fishes, but in many of the class it is absent. In all reptiles it exists. In some birds it is present; in others, absent. In mammals, also, it is not invariably present: the horse, elephant, and stag, for example, may be referred to as forming instances in point.

The secretion of the liver, or bile, forms a clear liquid, having a more or less viscid consistence, and a colour that ranges under different circumstances and in different animals through shades of green, brown, and yellow. In the human subject it is of a green or yellowish-green colour in its concentrated form, and becomes of a bright yellow on being diluted. Its taste is bitter, with a slight after-taste of sweetness. When fresh, it has very little odour; but what there is authorities describe as somewhat resembling in character the odour of musk. Its usual sp. gr. may be said to vary between 1020 and 1030. Its ordinary reaction Lehmann pronounces to be weakly alkaline, but says that it is often found perfectly neutral, and rarely, and then only in disease, acid. When poured into water it sinks to the bottom,

but on agitation readily mixes, forming a liquid that froths like a solution of soap. Indeed, chemically speaking, it may be regarded as constituting a kind of soap, and thus is accounted for the estimation in which ox-gall is popularly held as a detergent. It is generally described as being very prone to undergo putrefaction on keeping. Such is the case with weak or poor bile; but rich bile, I have repeatedly found, simply dries up on exposure to the atmosphere, without showing any signs of undergoing decomposition.

The chief principles of bile may be said to constitute its resinous and colouring ingredients. Besides these, however, it always contains: a small amount of cholesterine (a crystallizable, non-saponifiable fat); some neutral fatty matter; combinations of the fatty acids with alkalies; mucus derived from the biliary passages; various saline materials; and water. The proportion of solid matter amounts to about ten per cent. Beyond some epithelial particles derived from the mucous lining belonging to the canals through which the bile has passed, there is nothing under natural circumstances brought into view by means of the microscope.

Much difference of opinion has prevailed regarding the chemical nature of the resinous matter, forming one of the main ingredients of the bile. A variety of substances, now known to constitute only products of its decomposition, were formerly enumerated as if original constituents, and thus a most complex character was given to the composition that bile was represented to possess. Berzelius spoke of the resinous matter as a neutral or indifferent organic substance, and called it *bilin*. This bilin of Berzelius, however, according to the more recent researches of Liebig, Strecker, and

Lehmann, appears to consist of two peculiar resinoid acids combined with soda, so as to form a kind of soap. By Lehmann these have been named the *glycocholic* and *taurocholic* acids. He describes them as constituting what he calls conjugated acids; that is, bodies in which an acid is united with a basic substance which gives to it the possession of new properties, without, however, altering its saturating power. In the case of both the bodies under consideration, cholic acid it is which forms the acid *principle;* the basic substance, or adjunct with which it is copulated, being *glycine* on the one hand and *taurine* on the other.

Cholic acid is a non-nitrogenised body, the formula for which is $C_{48}H_{39}O_9, HO$. It approaches the fatty acids in character, and yields the same products of decomposition on distillation with nitric acid as the oleic acid. Whether in a free state or copulated with an adjunct, as it exists in bile, it may always be recognised by its behaviour with sulphuric acid and sugar. This reaction constitutes what is called Pettenkofer's test, and the following is the way in which it is applied. The liquid to be examined is treated in a test-tube with a drop or two of a dilute solution of cane sugar; and then, concentrated sulphuric acid is slowly poured in, taking care to avoid too great an elevation of temperature being produced. A cherry-red, followed by a beautiful purple colour, is produced when cholic acid is present.

Glycine, with which cholic acid is conjugated in glycocholic acid, is a body composed of carbon, hydrogen, oxygen, and nitrogen. It is the same as glycocoll, or sugar of gelatine, which has long been known as constituting one of the products of the decomposition

of gelatine by mineral acids and alkalies. Glycocholic acid in most animals forms the chief organic constituent of the bile. Being but very sparingly soluble in water, it is thrown down from its alkaline solutions by the addition of an acid. It is glycocholic acid which constitutes the dense precipitate produced when rabbit's bile is treated with an acid.

Taurine, in addition to the four elements met with in glycine, contains sulphur. Taurocholic acid, which results from the union of taurine with cholic acid, is more soluble in water than the glycocholic acid. It also has the power of dissolving fats, fatty acids, and cholesterine in large quantities, and its presence is the cause of glycocholic acid not being precipitable from fresh ox-bile and the bile of many other animals upon the addition of an acid.

The colouring matter of bile has not yet been separately obtained in a state of purity. Two kinds of colouring matter appear to exist—a brown and a green. The green is most abundant in the bile of the vegetable feeder. It forms the biliverdin of Berzelius, and was thought by this chemist to be identical with chlorophyll, the green colouring matter of plants. Professor Stokes, however, has recently recognised differences in the optical properties of the two which he considers sufficient to show that they are distinct from each other. In human bile the brown variety, which has been named cholepyrrhin, preponderates. It is this which produces the well-known reaction, or characteristic play of colours with nitric acid.

The biliary concretions which sometimes form in the gall-bladder, and thence may give rise to so much subsequent distress, almost invariably consist of choleste-

rine. Sometimes, however, it happens that they are composed of inspissated bile. But little, as yet, unfortunately, is known about the circumstances which lead to the formation of these concretions, and therefore our treatment rests upon a most imperfect basis. They are more common in women than in men, and are seldom met with in persons under thirty years of age. Sedentary habits seem to favour their production.

The most discordant estimates have been given concerning the quantity of bile secreted in man. Blondlot calculated that it amounted to about six or seven ounces in the twenty-four hours, whilst Bidder and Schmidt have more recently put it down at eight or nine times this quantity, or about fifty-four ounces. The estimates given have been drawn from the amount of bile discharged through biliary fistulæ established in the lower animals. Through the same means it has been ascertained that the flow of bile is continuous, but presents fluctuations. Its minimum flow is at a period of fasting. Shortly after the ingestion of food the flow begins to augment, and continues increasing until its maximum point is reached, which is not till after the completion of digestion.

Bile must be regarded as having several purposes to fulfil. There are three points of view under which it may be examined, viz.—

1. As an excretion.

2. As a secretion containing elements for re-absorption.

3. As a secretion affording assistance in the digestive process.

It is its colouring ingredient that renders bile in part an excretion. That this portion is simply destined

for elimination from the system, is rendered evident by various considerations. In the first place, it accumulates in the intestine, forming part of the meconium during intra-uterine life, and is discharged from the system shortly after birth. It further forms throughout life a constituent of the alvine evacuations. The colour of the dejections, indeed, is due to the colouring matter of the bile; hence when bile is from any cause prevented from flowing into the intestine, the motions present a more or less colourless appearance. Again, when the escape of bile through its natural channel is obstructed, its colouring matter accumulates in the system, occasioning jaundice, and is then found, like other products of the system intended for excretion, to be vicariously discharged through other channels.

As the urine is characterised by its richness in nitrogen, so is the bile by its richness in carbon; and Liebig long since broached the idea, that a great part of the bile was re-absorbed from the intestine, and subsequently utilised in the system by contributing towards heat-production. The point at which the bile is discharged, necessitating, as it does, its traversing the whole length of the intestine before it can be expelled, affords *primâ facie* grounds for concluding that it has something to do besides playing the part of a pure excretion. Now, Bidder and Schmidt's experiments have shown that a re-absorption of a portion must actually occur, it having been found that the whole solid residue of the intestinal evacuations of a dog subsisting upon a flesh diet scarcely amounted during a given period to what would be contained in the bile that flowed from the liver. It is therefore evident that a large portion of the secretion must have been re-

absorbed during its passage along the intestinal canal, and it is its resinoid portion which thus disappears.

But the bile must further be looked upon as a secretion designed for affording a share of assistance in the digestive process, and as such it will now be spoken of.

In the first place, then, the alkali it contains contributes to destroy the acidity of the gastric juice after this has fulfilled its purpose, and its presence is no longer needed. It is easy to show upon the rabbit that as the acid chyme reaches the intestine and comes in contact with the bile a chemical reaction of these fluids upon each other takes place, which is attended with the displacement and precipitation of the resinoid acid principle from the bile.

There is nothing to indicate that the bile exerts any digestive influence upon either the nitrogenized or amylaceous elements of the food. Upon some fats, however, it is capable of acting. The neutral fats escape, but the acid fats are emulsified by it. Now, it happens to be the neutral fats that we principally consume with our food; but Dr. Marcet says that these neutral fats are in part acidified in the stomach, and so rendered apt for yielding to the emulsifying influence of the bile. The pancreas, however, seems fully equal to the performance of all that is wanted in connection with the digestion of both the neutral and acid fats. The co-operation of the bile, which, at the most, enjoys only a limited action, as already mentioned, upon fats, is therefore not absolutely needed.

The bile also serves as a stimulus to excite the glandular follicles and muscular fibres of the intestine to proper action: hence, the constipation that is

so commonly encountered in cases of jaundice, where its flow into the intestine is obstructed; the diarrhœa that attends its too copious secretion; and the purgative effect obtained by the administration of ox-gall.

Although contributing to the purposes named in connection with the process of digestion, yet experiment shows that its presence in the intestine is not absolutely indispensable. When the bile-duct of an animal is simply occluded, death follows as an inevitable consequence, from the retention of bile in the system. If, however, with the occlusion of the duct, an artificial means of escape be provided for the bile, recovery from the operation may take place, and life continue without any serious evidence of disturbance. At first great emaciation follows the operation, but afterwards restoration to a fairly healthy condition has been observed. A more abundant allowance of food, however, has been found necessary than under ordinary circumstances, in order apparently to compensate for the loss of a secretion which is in part designed for re-absorption.

The physiological action of the various secretions poured into the intestinal tract having been separately examined, it now remains for the phenomena of intestinal digestion to be spoken of in a connected manner.

Chyme, as the semifluid material is called, which passes from the stomach into the intestine, contains albuminose, or the product of gastric digestion; the nitrogenized digestible matters that happen to escape through the pylorus before being completely digested; nearly all the starchy matter consumed, a very insignificant portion only having been as yet transformed into sugar and absorbed; all the fatty matter that has been ingested, this having been liquefied by the heat of the

stomach, and become divided into globules, but not emulsified; and the indigestible or insoluble parts of the food.

Reaching the intestine, the chyme becomes progressively incorporated with the several secretions poured into the canal, and by the agency of these the following changes are effected:—The starch that is present is gradually metamorphosed into sugar, which is absorbed by the blood-vessels, and carried to the liver as fast as it is formed; the fatty matter is emulsified, and so fitted for absorption by the villi from which it is subsequently poured into the lacteals; and, lastly, the nitrogenized alimentary principles that have escaped digestion in the stomach continue to be acted upon and to be dissolved. To sum up: the intestine, it may be said, forms the seat of digestion of the non-nitrogenized alimentary principles—starch and fat; and further discharges the supplementary office, as regards the stomach, of digesting the non-nitrogenized aliment that happens to escape solution in that viscus.

The fluidity of the chyme is at first increased by the secretions with which it is brought in contact in the upper part of the intestine, but as its onward flow takes place it becomes diminished by the activity with which the process of absorption is carried on. In the large intestine the removal of fluid by absorption preponderates over its exudation by secretion to a sufficient extent to lead to the solid consistency which the excrementitious residue is found to naturally acquire before its expulsion from the system.

The reaction of chyme on its entrance into the intestine is always to a marked extent acid, owing to the

acid nature of the gastric juice that it contains. The secretions encountered in the duodenum have the effect of materially diminishing the acidity that is thus communicated by the stomach; and, the intestinal juice exerting a similar action, by the time the lower part of the ileum is reached, the intestinal matter may be found to present a neutral or even an alkaline reaction.

In the herbivora the contents of the alimentary canal again acquire a strongly acid reaction in the cæcum, and it has been suggested that a kind of second process of gastric digestion is here performed. The acidity, however, it is to be remarked, is due to the development of acid through changes occurring in the contents, and not to the secretion that is poured out; the secretion of the cæcum, in fact, being alkaline, like that of the other portions of the intestinal tract. It may be further remarked, that from the mucous membrane of the cæcum no infusion possessing digestive properties when acidified is to be procured, like what can be obtained from the mucous membrane of the stomach.

The colour of the contents of the stomach depends upon the nature of the food. In the duodenum the chyme is brought into contact with a highly coloured fluid—the bile; but the influence of this on the alimentary matter is at first obscured by the opaque whiteness of the emulsified fatty matter, and the precipitation of resinoid matter which takes place from the bile itself. Thus it is that in the upper part of the small intestine a cream-like appearance is presented by the contents. In the lower part, however, on account of the extraction that has been effected by absorption, a more or less deep yellow colour is observable, which is shown to be dependent on the colouring matter of the bile,

by the behaviour that is noticed on the nitric acid test being employed. In the large intestine a transformation of the yellow colour into brown is brought about, and now nitric acid fails to develop the reaction of bile. When bile is prevented from reaching the intestine, as in cases of jaundice, it is well known that the dejections are voided in an almost colourless condition. This affords strong evidence that the colour of the fæces is due to the colouring matter of the bile.

A special odour belongs to the dejections, which varies in different animals. The odorous principle, agreeing as it does with the odour that is specific to the body of the animal and that appears in various degrees of intensity in all its different excretions, is doubtless derived from the blood. It has been suggested that it is from the bile that the fæcal matters acquire it, but there is greater probability that it is from the intestinal glands that it comes. What is to be noticed in the fowl has strongly convinced me personally that the latter is its true source. A pair of long, narrow, cæcal appendages, for instance, are met with in connection with the intestine in the fowl, which are pointed to as marking the separation between the small and large divisions. They form glandular processes, and are not traversed by fæcal matter. Now, on laying these cæcal appendages open the characteristic odour of the fæces of the animal is found to be evolved in a very concentrated form.

Various gases are encountered in the alimentary canal. Amongst these, oxygen, nitrogen, hydrogen, carbonic acid, and carburetted and sulphuretted hydrogen, have been recognised. The two first are doubtless principally, if not entirely, derived from the air, which is entangled amongst, and, thus constantly being

swallowed with, the food. The others must arise from the changes that occur in the food or secretions, or else form products of elimination by secretory action direct from the blood. That such an elimination of gas can take place from the blood is evidenced by what is observed in the case of the swimming bladder of the fish; and also by the fact, that an odorous gas, which has been received into the system through the lungs, is afterwards found, from the odour presented by the dejections and flatus, to have unmistakably reached the interior of the intestine. In the experiments that have been made on the intestine with reference to this matter, it has been found that an empty coil enclosed between a couple of ligatures has become subsequently distended with gas. It must not be concluded, however, that the gas which has accumulated under these circumstances has necessarily formed a product of secretion, for it might with equal probability have been derived from the occurrence of decomposition within, it being impossible to exclude all source for the generation of gas in this way.

The period of time taken for the transit of matter through the intestinal canal varies considerably in different individuals and under different circumstances. Under the existence of diarrhœa, the whole length of the intestine may be traversed in a couple of hours, whilst, on the other hand, weeks, or even months, it may be said, have been occupied in cases where mechanical obstruction has existed. Probably about twelve hours is the time ordinarily taken for transit through the small intestine to be effected, and about thirty-six hours for the sojourn of matter in the large.

The accumulation of fæcal matter at the lower

extremity of the alimentary canal occasions an impression which creates a desire for its expulsion from the system. Under the influence of habit, the desire thus created may be made to recur with the utmost regularity. Nothing, indeed, can be more complete than the regularity with which the alimentary canal can be brought to discharge its defæcative function, and nothing is more necessary for health than the cultivation of a regular habit in this respect. Where it occurs that the call of nature is frequently neglected to be responded to, through the accumulation that is thereby allowed to ensue, the mucous surface of the rectum loses its natural impressionability and the muscular fibres their tone; the distension becomes greater and greater, and the power of expulsion correspondingly less, until it arrives that the artificial aid of a purgative or an enema requires to be had recourse to in order to procure an evacuation. Thus, by a simple want of attention, in the first instance, to the dictates of nature a host of miseries may be occasioned: for, dejection of spirits, derangement of the stomach and liver, hæmorrhoids, and a multiplicity of other ills, follow as attendants upon constipated bowels.

It is by the presence of foreign matter in the vicinity of the outlet of the canal that the act of defæcation is excited, and thus it arises that the introduction of a bread suppository into the rectum is often sufficient in the child to produce an action of the bowels. Defæcation is essentially a reflex-spinal act. The will, however, can exercise a controlling influence over its performance. A little voluntary straining brings the egesta within the sphere of distribution of the incident, or excitor nerves connected with the process, and a de-

finite reflex movement is the result. After the experimental division of the spinal cord it is found that the application of a stimulus to the lower end of the rectum excites a series of rhythmic movements which result in the complete performance of defæcation, when anything exists in the neighbourhood of the outlet to be voided. Under such circumstances it is evident that neither the will nor sensation can have had anything to do with the phenomenon. Fortunately for our comfort, however, it is found that, when the will is free to operate, a restraining influence can be exercised by it over the performance of the process. Still it may arrive, where a high state of morbid irritability happens to exist, that the influence of the stimulus tending to the production of reflex action may be stronger than the controlling power of the will; and thus, in spite of all the voluntary effort that can be brought to bear to the contrary—in spite of all the voluntary power that can be thrown upon the sphincter towards keeping it in a state of contraction—the act of expulsion is found to result.

The matter ejected from the alimentary tract by defæcation consists of (1) the materials that are found to be refractory to the solvent influence of the various secretions poured out for digestion; (2) whatever of a digestible nature may chance to escape undergoing digestion and absorption (the microscope, for instance, may display starch-granules and other vegetable elements, muscular fibres and other elements of animal structures, and fatty matter); and (3) various products, such as epithelium, mucus, the colouring matter of bile, &c., derived from the digestive organs themselves. The meconium or excrementitious matter

first expelled from the alimentary canal after birth entirely consists of products derived from the digestive tract and its glands.

Dr. Marcet has separated a special product of excretion from the alvine dejections, to which he has given the name of *excretine*. This substance, which he has obtained in a crystalline form, closely resembles, he says, chloresterine in its properties; and, further, he thinks, has some physiological connection with cholesterine, inasmuch as he has found the excreta of very young children to contain cholesterine and no excretine, whilst exactly the reverse has held good in the case of young people and adults.

COLIC.—ENTERALGIA.

When a muscle is thrown into a state of unnatural, or spasmodic contraction, pain constituting cramp is the result. The muscular fibres of the intestine are not exempt from liability to be thrown into this irregular mode of action, or spasm; and what is called colic, belly-ache, or the gripes, forms the complaint resulting therefrom. A variety of causes constitute excitants of this condition, and upon the nature of the cause will depend the degree of import belonging to the affection, which may range from one of a trivial and passing nature to one of the utmost gravity and danger. It should be always borne in mind that colic, if not overcome, may, by the deranged action arising from the obstruction produced, pass into enteritis, or acute inflammation of the bowel. Through irregularity of muscular action, also, one portion of bowel may become accidentally inserted into another, forming what is known as intussusception—a condition more particularly encountered in infancy and childhood.

The causes of colic, or the conditions giving rise to spasmodic contractions of the intestinal muscular coat, may be grouped into: sources of irritation existing within the canal; abnormal states in respect of structure and position of the intestinal tube; contamination of the system with lead; and certain general and

remote affections implicating in a secondary manner the muscular fibres of the intestine.

The sources of irritation within the canal that may produce colic comprise such as flatus, worms, irritating ingesta of any kind—whether of the nature of food or otherwise, morbid secretions, intestinal concretions, and unduly retained excrementitious matter. Idiosyncrasies exist, and an article that is food for one man may be poison to another—setting up violent derangement accompanied with colic.

As regards colic attributable to the condition of the intestine itself, anything which causes an occlusion of the canal or impedes the passage of its contents will lead to irregular action of its muscular fibres above the seat of obstruction, and thus occasion colic. Morbid structural conditions leading to constriction, hernia, and internal strangulation from whatever cause arising, act in this way. An inflamed, ulcerated, or any diseased state, which renders the mucous surface morbidly irritable, may be the source of colic, through the increased readiness with which undue muscular contraction is excited.

With respect to colic arising from general and remote causes, contamination of the system with lead is a well-known source of one of the most severe forms of the affection that is met with. As occasional exciting causes falling under this head must also be enumerated strong passions and emotions in persons of a nervous or irritable temperament, exposure to cold, dentition, and uterine derangement. The hysterical and gouty dispositions form habits of body which predispose to the occurrence of colic.

The treatment of colic must be regulated by what

is found or believed to be its exciting cause; but purgatives, anodynes, narcotics, and antispasmodics, administered by the mouth or used as enemata, are the medicinal agents that will have to be selected from, according to the circumstances of the case. Friction with stimulating liniments, hot fomentations—medicated and simple, and the mustard poultice or turpentine stupe, applied to the abdomen, often assist materially the other measures adopted. The warm bath has also a powerful effect in overcoming spasm, and should, therefore, in obstinate cases, not be left untried. When a free action of the bowels can be obtained relief is generally afforded.

The particular treatment required for colic arising from structural disease, mechanical displacement, and obstruction of the intestine, and also from lead poisoning, would be beyond the purport of this work to refer to.

It is probable that, as with the stomach, a morbid sensitiveness of the mucous membrane of the intestine may sometimes exist and constitute, instead of colic, the cause of pain referable to this portion of the alimentary canal. Enteralgia and enterodynia are names given to this condition, about which but little of a definite nature can be said. Abercrombie speaks of four forms of gastralgia, and refers one of them to a painful condition of the first part of the small intestine. Pain, for example, beginning from two to four hours after a meal, and continuing for some hours—a form of complaint that is not unfrequently encountered—Dr. Abercrombie thinks, is probably seated in the duodenum and connected with inflammatory action or morbid sensibility of its mucous membrane. This form of affection, continues Abercrombie, is often accompanied with pain and ten-

derness on pressure in the right hypochondrium, and on that account is apt to be mistaken for disease of the liver.

As regards treatment, what has been said under the head of gastrodynia may be taken as applying also to enteralgia.

INTESTINAL FLATULENCE.—TYMPANITES.

The inordinate accumulation of gas in the stomach has already been treated of. As the result of deranged intestinal action, gas is also apt to accumulate to an unnatural extent in the intestine. It may arise from exhalation from the mucous surface (at least there are good grounds for believing so); or, form a product derived from the occurrence of changes of decomposition amongst the contents of the canal.

The presence of flatus in the intestine may give rise to irregular contraction of the muscular coat accompanied with pain constituting colic. The movement of the flatus is often accompanied with rumbling noises in the abdomen, which are termed "borborygmi." In some cases the fibres of the colon contract around an accumulation of gas and make it appear that a circumscribed tumour exists. This can be moved about like an ordinary tumour, and in other respects may feel so like one as to render it difficult to convince the patient that no actual morbid growth exists. The patient will admit that sometimes it can be felt, at other times not; and not unfrequently, that it is sometimes to be found on one side and sometimes on the other side of the abdomen. Its phantom nature is shown by the sudden disappearance that may be generally induced by a little manipulation. Percussion clearly discloses in reality when it is a flatulent accumulation that has to be dealt with.

When the distension of the intestine with gas is general a swollen and resonant or drum-like state of the abdomen is produced, which constitutes what is known as tympanites. In various adynamic forms of disease there seems to be such a loss of tone in the muscular tissue of the alimentary canal that no power exists to expel the gas that accumulates, and thus the tympanitic distension of the abdomen may become such as to form, not only the most distressing, but even the most alarming feature of the case.

In ordinary flatulence of the intestine the treatment should be directed towards correcting the state of the secretions that may be out of order, and improving the digestive powers and tone of the alimentary canal. The diet should be regulated: all indigestible articles of food being avoided. As in flatulence of the stomach—and it is only anatomically that the two affections are separated—carminatives and antispasmodics are often needed for temporarily relieving distress.

For the treatment of tympanites—carminatives, stimulants, and antispasmodics, administered by the mouth; enemata of rue, assafœtida, and turpentine; friction of the abdomen with stimulating liniments; and stimulating epithems applied to the abdomen form the medicinal resources at the disposal of the practitioner. In extreme distension it has been recommended to draw off the gas through a flexible tube introduced into the colon. The process has been tried, and cases are reported in which it has been attended with success. By its means it is stated that Dr. Osborne, of Dublin, upon one occasion reduced a tympanitic abdomen in about an hour to nearly its natural size.

DIARRHŒA.

By the peristaltic action of the intestinal muscular fibres the alimentary matters are propelled through the small intestine at that rate of speed, under natural circumstances, which allows intestinal digestion to be completely carried out, and absorption of the products, both of gastric and intestinal digestion, to be thoroughly effected. The unabsorbed residue is transmitted from the small into the large intestine in a semifluid state. Here the transit is slower, and absorption of fluid is carried on so as to give a condition of solidity to the egesta before their discharge from the body takes place. Now, if from any cause the alimentary matters are unnaturally hurried along the intestinal canal; or the elimination of fluid from the intestinal glands is in excess; or its removal by absorption in default, the evacuations will fail to possess a natural consistence—in other words, will be loose and watery. As an almost invariable consequence of such a state, a more frequent call than is natural for the performance of defæcation is excited, and thus diarrhœa, which is understood to signify the occurrence of frequent and loose alvine evacuations, is said to be established.

The manifestation of deranged action of the intestine now under consideration forms one of the commonest complaints that the medical practitioner is called upon

to treat. It may either occur in the course of—as a symptom of, another disorder, as, for example, typhoid fever, phthisis, &c.; or present itself as a primary and independent affection. Under all circumstances it arises from an influence morbidly affecting either the muscular or mucous coat, separately or together, of the intestine.

Diarrhœa may be suddenly induced in a susceptible person by a mental impression, particularly, for instance, by the operation of a depressing emotion, such as grief or fear. Rumbling and gurgling noises are heard in the abdomen; and soon, loose alvine evacuations are passed, which must be referred to an increased peristaltic action of the muscular coat as their cause.

Far more frequently it is the mucous coat that is primarily concerned in the production of diarrhœa. A variety of causes contribute to establish a state of irritation or inflammation of this coat, by which diarrhœa is set up. Its secreting and absorbing functions become deranged in action, and excited peristaltic movements of the muscular coat are secondarily induced.

It has just been stated that a variety of causes concur in morbidly affecting the mucous coat, so as to occasion diarrhœa. In the diarrhœa of typhoid fever, and in that which occurs in the course of some other allied disorders, it is through a septic poison developed in the system that the morbid condition is brought about. The foul effluvia emanating from drains and cesspools, and atmospheric miasmata of other kinds will sometimes rapidly give rise to diarrhœa. Here the effect must be attributed to the absorption of an agent through the lungs that has the property of acting as

an irritant upon the intestine. By the flatus that is expelled under such circumstances presenting more or less the odour of the atmosphere that has been breathed, it may be assumed that it is in the fulfilment of an eliminative office that the intestinal mucous membrane becomes affected.

The most common cause of diarrhœa is the presence of something in the intestine which acts as a topical irritant to its mucous coat. It may be that an actual irritant poison has been swallowed; or, simply that something of an irritating nature has been ingested with the food—that something, in other words, has been taken which, as the phrase goes, "has disagreed;" or, it may be, that a discharge of vitiated bile forms the source of the disorder. Exposure to damp and cold may affect the mucous membrane of the intestine, as it does so frequently that of the respiratory passages, and thus again may diarrhœa be set up. Lastly, diarrhœa arising from a morbid condition of the mucous membrane may be produced by a constitutional, or internal cause.

In some cases of diarrhœa—*diarrhœa lienterica*—the ingesta pass through the alimentary canal almost unchanged. This form of diarrhœa mostly occurs amongst children, and is frequently observed as a concomitant of tabes mesenterica. It is evident that the digestive as well as the absorbing powers are seriously at fault. The appetite is usually voracious, and, from the food failing to reach its natural destination, extreme emaciation and debility become in the course of time established.

The treatment of diarrhœa must be shaped according to the nature of the cause that has determined it.

In that dependent on a mental influence, if it should

not subside by itself, a few doses of a sedative will be usually found to effect all that is required.

In the diarrhœa which is consequent upon the ingestion of an offending article of food the first object is to get rid of the noxious agent from the *primæ viæ;* the next, to control the effects resulting from its irritating action upon the mucous lining. The vomiting and purging that are occasioned by the presence of irritant matter in the stomach and intestine must be looked upon as salutary efforts of nature designed to expel an offending agent from the system: hence such phenomena ought not at first to be checked. But, it may afterwards arrive, that the morbid action is kept up by the state of the mucous membrane that has been induced; and now, soothing or controlling measures are required.

In this form of diarrhœa, therefore, the *diarrhœa crapulosa* of Cullen, which is accompanied with nausea, and may be, with vomiting, a white and furred tongue, foul breath, fetid evacuations, flatulence, griping pains in the bowels, and an absence of fever, the appropriate remedy at the onset is something to assist nature in expelling the source of irritation from the alimentary canal. If the case be seen at the beginning a purgative, with which it is desirable to conjoin an anodyne, should be given: as, for example, from two to five grains of calomel with half a grain of opium; or fifteen to twenty grains of rhubarb with half a grain of opium; or an ounce of castor oil with ten drops of laudanum. At a later stage something to exert a restraining influence should be administered, and what is usually given consists of chalk mixture, with an opiate, an aromatic, and a vegetable astringent.

In the diarrhœa which forms so prevalent a complaint towards the end of summer and the beginning of autumn; and which seems to depend as much, or more, on atmospheric conditions as on the ingesta; the astringent combination that has just been referred to may be commenced with immediately. Another treatment for this kind of diarrhœa, and one which sometimes proves very successful and a short time since had great popularity, consists of the dilute sulphuric acid, which may be given in doses of from twenty to thirty drops with a little syrup in an ounce of water.

Rest in the recumbent position, hot fomentations, or even a turpentine stupe to the abdomen, form important adjuvants in a case of severity.

It may be, notwithstanding the remedies administered, that the diarrhœa continues, and that the flux is so profuse as to call for the use of a mineral astringent. The acetate of lead is found to be the most efficient for the purpose. It may be given in two-grain doses, with half a grain of opium, every three, four, or six hours, according as it is seen the circumstances of the case require.

For the diarrhœa of phthisis, and for administration in many other cases where diarrhœa is met with in its more chronic form, I am induced to speak in terms of high commendation of a mixture—the Mistura Hæmatoxyli composita of the Guy's pharmacopœia, which is thus composed:

℞ Misturæ Cretæ, f℥xij;
Extracti Hæmatoxyli, ʒij;
Vini Ipecacuanhæ, fʒij;
Vini Opii, fʒj.
Misce, et detur fluidunc. j bis, ter, sæpiusve quotidie.

For checking the loose stools that occur in typhoid

fever and some other morbid states nothing is found to act more efficaciously than an opiate clyster or suppository. Thirty minims, for instance, of laudanum in about four ounces of barley water or decoction of starch may be thrown into the rectum; or ten grains of the soap and opium pill be used as a suppository, as often as occasion may happen to require.

In the diarrhœa of infants, arising either from improper or unwholesome food or from the irritation of teething (a class of case which is so frequently encountered by the physician in the out-patient practice of an hospital), I am in the habit of giving, and with the most satisfactory result, a little ipecacuanha, with a bitter and a saline. My prescription consists of a few minims of the Vinum Ipecacuanhæ, twenty minims or so of the tincture of calumba, and one to two or three drachms of the Mistura Salina of the Guy's pharmacopœia, which is made by saturating a solution of carbonate of potash, containing twenty grains of the carbonate to each fluid ounce of water, with lemon juice. Conjoined with this, a couple of grains of grey powder are sometimes given as an alterative every morning; or, sometimes, a powder consisting of a quarter or half a grain of calomel, two grains of the dried carbonate of soda, and five grains of the aromatic powder of chalk.

In the form of diarrhœa now being spoken of there exists a state of irritation of the whole gastro-intestinal tract. The appetite is capricious—sometimes ravenous, at other times absent. The tongue is white in the centre, red at the tip and edges. The breath has a sour smell. Occasionally there is vomiting. The abdomen is swollen and tympanitic, and more or less tender.

The motions are unnatural in colour—generally green, like spinach—and exceedingly offensive. The child is peevish and fretful, and its sleep is disturbed. Emaciation, particularly in the limbs, rapidly proceeds; and, where the morbid condition is allowed to run on, a state of marasmus, with mesenteric disease, becomes established. There is frequently with the train of symptoms referred to more or less accompanying bronchial complication, indicated by cough and rattling or wheezing at the chest. Here, a few minims of the syrup of poppies added to the mixture above mentioned will prove beneficial.

The diet in diarrhœa should consist principally, if not exclusively, of farinaceous articles of food—such as rice, sago, tapioca, arrowroot, corn-flour, and bread—with milk, and chicken or mutton broths. Beef-tea, it should be remembered, will sometimes by itself produce in a weak person a looseness of the bowels. Green vegetables and fruit are to be proscribed.

In the infantile diarrhœa, above alluded to, it is requisite to give particular injunctions respecting the diet; for, it is upon the food that has been already given, that the existing malady very often depends. It being only after birth that the digestive organs begin their functional activity, the digestive powers of the infant are in their very incipient stage of activity, and are thus only adapted for a while for the mildest form of food. The weakness or susceptibility, indeed, of the alimentary canal that exists at this period is shown by the manner in which a child at the breast is often affected by a slight indiscretion, as regards eating and drinking, on the part of the mother.

When the food provided by nature for the first period

of life is changed—or the child is weaned, the transition should be gradually made; and, not until after the more easily digestible articles of food have been for some time given, should those that are more difficult of digestion be allowed. And yet, ignorance of the laws of life is found to prevail to such an extent, especially amongst the poorer classes, that it is not uncommon to hear that anything, whether it be green vegetables, salt meat—or, indeed, it does not signify what—that comes to the parents' table, is given to a child that has only just been weaned, or even to a child that is still being suckled. The mother seems to have no idea that the digestive powers of her infant are weaker than her own, and wonders what it can be that has set the system wrong—has produced the illness for which the child is brought to be treated; but with its imperfect masticatory organs and immature digestive powers, it is not surprising to find that a disordered state of the stomach and bowels has been induced. The point of first importance to be attended to in such cases is to restrict the diet to the most easily digestible articles of food. Without this, no medical treatment will prove of any avail.

Speaking of the ignorance that may prevail upon the subject of food, I once met with a child in my out-patient practice that was being brought up by hand upon arrowroot and water! The mother had lost her milk, and was feeding her infant in this way, having always heard as she said that arrowroot was considered an exceedingly nourishing article of food. It is not surprising, as this had been carried on for some little time, that the child was one of the most emaciated I have ever seen.

CONSTIPATION.

The residuary matter that escapes digestion and absorption requires to be expelled from the alimentary canal, and for the maintenance of a healthy state such expulsion must be periodically effected at not very lengthy intervals. One alvine evacuation daily is what is customary with most individuals. With some persons, however, two, or even more, dejections during the twenty-four hours may form the rule, a state of discomfort being experienced should the accustomed frequency fail to be observed. With others, on the other hand, only one action may take place every second day, or even longer, and still be consistent, if of regular occurrence, with a perfect state of bodily health.

With the above preliminary statement, constipation may be defined as a prolonged retention of the fæces, with more than ordinary difficulty in expelling them. It constitutes one of Cullen's symptoms of dyspepsia; and, popularly, is often confounded with, or looked upon as synonymous with, indigestion. It certainly forms a result of deranged action of a portion of the digestive system, and frequently, though still not by any means universally, accompanies indigestion in the ordinary acceptation of the term.

Instances of constipation are not uncommon where intervals of several days, or one or two weeks, and

even more, are found to occur between the motions that are passed. Instances, however, have been placed on record where intervals of an almost incredible duration have occurred—intervals, for instance, that could be reckoned by months instead of only by weeks or days. A case is quoted from a French source, by Dr. Copland, in which, from the earliest period of life, stools were seldom passed oftener than once in one or two months; and at the age of forty-two the time was usually prolonged to three or four months. The subject of the case was a medical officer in the French service. He died at the age of fifty-four, and on examination after death a fibrous partition was found obstructing the rectum about an inch above the anus. Above the source of obstruction the rectum was so enormously distended as to fill up the pelvis and a great portion of the abdomen, which had assumed a very large size. The lower part of the colon was enlarged to the size of the stomach. It is stated that the colon and cæcum, in other cases of constipation, have been sometimes found to measure from twenty to thirty inches in circumference.

Constipation, in a general way, is more common in females than in males; and, females of a delicate habit of body, with a weak or atonic condition of muscular fibre, are more prone to it than others. Sedentary habits also form a predisposing cause.

The most common immediate cause of constipation is a torpid condition of the parts administering to fæcation. With the secretion of the colon defective in amount, and its muscular coat in a sluggish or relaxed state, favorable circumstances are presented for an undue retention of its contents. These, by the process

of absorption that goes on, become reduced to a state of preternatural consistence; and, are thus rendered more and more difficult of expulsion the longer they are retained.

In the constipation which forms an accompaniment of colic from lead poisoning a contracted instead of a relaxed state of the muscular coat is believed to exist, and to form the cause of the phenomenon. Through the resistance offered to the transit of matter along the intestinal canal by the existence of a spasmodically contracted state of its muscular coat, constipation would be looked for as a natural result. Relief, accordingly, in this form of constipation is found to be afforded, not by powerful purgatives, but by measures directed towards removing the spasmodic muscular contraction which is at one and the same time the source of the colic and the constipation.

There are various conditions which produce constipation in a mechanical way, by either obstructing the passage of the intestine or interfering with the performance of defæcation.

Obstruction to the passage of fæcal matter along the intestine, for instance, may arise from the lodgment of scybala or intestinal concretions within the intestinal canal; from structural disease in the walls of the intestine, leading to a constriction of the passage; or from compression or constriction arising from causes external to the canal itself—such as the pressure of the gravid uterus, a tumour, or an abscess, and the constriction arising out of a hernial protrusion, or produced by a band of adhesion, or something of this kind within the abdominal cavity.

The performance of defæcation may be interfered

with through the existence of hæmorrhoids, which form a frequent source of constipation. Fissures of the anus also impede defæcation, and so lead to constipation, but in another kind of way. Through the reflex influence of the irritation arising from the fissure, the sphincter muscle is kept in such a forcible state of contraction as to offer an unnatural resistance to the expulsion of matter from the rectum.

Constipation as an habitual derangement is only viewed in general as an affection of minor importance, and for its removal some household aperient is generally kept, and had recourse to. When constipation, however, does not yield to the remedies employed, but begins to show signs of being of an insuperable nature, it becomes a grave and urgent affection, being one that may be followed by the most serious consequences.

The morbid conditions that constipation may occasion are of various kinds.

Under an undue retention of fæcal matters within the colon noxious products may be formed there, and act as irritants upon the mucous coat, setting up inflammation, followed by ulceration. It is to be here remarked that fæcal matters are sometimes retained in the sacculi, or pouches of the colon, and may give rise to the consequences referred to, whilst a passage exists along the centre of the canal that shall permit a daily evacuation to occur. The dejections, even, may be loose in character and still the same sequence of events ensue. From the irritating influence of preternaturally retained fæces, colicky pains are, as a rule, induced, and the ultimate effects may be such as to lead to the production of fatal inflammation.

The effect of constipation upon the muscular coat of the bowel is, through the distension to which it is subjected, to weaken or deteriorate its evacuating power. As the result of a great amount of distension, like as happens in the case of the urinary bladder, more or less complete paralysis is induced.

From the prolonged retention of fæcal matter accompanying constipation, excrementitious products that ought to be eliminated become absorbed and thereby contaminate the contents of the circulatory system. As the result of this contamination, the secretions become vitiated, and a general disturbance of the functions of life is produced. The action of the liver becoming deranged, its eliminative office is imperfectly discharged, and thus sallowness of the face and a bilious-tinged conjunctiva are produced. A coated tongue, foul mouth, loss of appetite, and other dyspeptic manifestations, accompany the general disorder of the digestive organs that prevails. The accumulation existing in the colon leads to a sense of distension and uneasiness in the abdomen. The kidneys vicariously discharge products that ought to have been eliminated by the alimentary canal. In this manner the urine becomes preternaturally loaded. From the contaminated state of the blood the functions of animal life also become disturbed; and hence the lassitude, debility, headache, giddiness, and dejected spirits, that form such frequent accompaniments of costiveness.

Other evil consequences have yet to be enumerated as produced by constipation. Through the mechanical influence of the accumulated matter in the large intestine, the return of blood from the rectum is in a direct manner impeded. The deranged action of the

liver, induced, as above mentioned, by the contamination of the blood with excretory products, will also tend to occasion a similar state by its influence generally on the portal circulation. Thus a condition is established which is prone to lead to the formation of hæmorrhoids and the occurrence of hæmorrhage from the rectum.

A distended cæcum, colon, and rectum, may also, by the pressure exerted upon the nerves and vessels of the lower extremities, be the cause of numbness, cramps, pains, and œdema of the legs. The œdema occasioned by constipation, if not exclusively confined to one side, will in all probability be decidedly greater in one leg than the other.

The undue straining efforts at stool, again, which constipation calls forth, may lead to hæmoptysis in the young, and apoplexy or hernia in the aged.

In the treatment of constipation occurring as a manifestation of functional derangement, and it is to this form of constipation that the remarks on treatment will be here confined, the object in view is to excite the glands and muscular fibres of the large intestine into increased activity. This is effected by the class of remedies denominated purgatives, which includes a great variety of agents differing considerably in degree of power and in precise mode of action from each other.

It is the laxative group, or milder form of purgative that is usually required in cases of constipation, and moderate doses, repeated at short intervals, are better than larger doses at longer intervals. A violent action is succeeded by the production of an opposite condition, and it is the occurrence of torpor which it is so desirable to prevent. The effect that is wanted is not an occa-

sional violent action, but a continued moderate activity of the bowels. Instead, for instance, of a couple of aperient pills being taken together at bed-time, which it may be presumed in the ordinary way will be followed by free purging the next day, one pill, repeated as often as occasion may require to obtain and keep up a periodical movement of the bowels, will be attended with a far more salutary result. In a matter of this kind, such a variable amount of artificial aid being required in different individuals to produce the effect desired, the personal experience of the patient must be consulted as a guide. The assistance afforded should be just such as suffices to bring about the accomplishment of what nature ought to perform, and no more.

A great variety of agents are placed at the disposal of the practitioner for the removal of constipation.

Rhubarb, colocynth, and aloes, are valuable remedies and very largely used.

Podophyllin, a more recently introduced medicinal agent, is also in extensive use. Its effect, however, is somewhat uncertain; for, whilst its action in some cases is everything that could be desired, in others it may be followed by very violent disturbance.

Senna is a safe and excellent purgative, and the syrup of it, prepared according to the 'British Pharmacopœia,' has this advantage especially for administration to children, that it is not an unpalatable preparation.

Dried ox-gall used in the form of pill often produces without any discomfort just the effect that is required in cases where it happens that the bowels are not over difficult to move.

Sulphur relaxes without occasioning any griping or

distress, but it only forms a remedy of very mild energy.

Various saline agents are also used as purgatives. Seidlitz powders and the granular effervescing citrate of magnesia form agreeable and popular preparations of this class, but they are often very far from active enough for what is wanted. What is ordinarily sold as the granular citrate of magnesia in reality, it appears, consists of the citrate of soda, this, the druggists say, being preferred by the public on account of being free from the slightly disagreeable taste which belongs to the magnesian salt. Messrs. Bullock and Reynolds, of Hanover Street, prepare a granular effervescing saline aperient, which consists of tartrate of soda with a little citric acid and sulphate of magnesia. It may be regarded as a kind of Seidlitz powder rendered more active by the incorporation of sulphate of magnesia, and is not unpleasant to take.

Certain mineral waters act very desirably in many cases of constipation. The Püllna water contains sulphate of magnesia as its active ingredient. A tumblerful taken before breakfast and repeated a few mornings will generally afford the relief that is desired. The Carlsbad and Marienbad waters enjoy purgative properties which they owe to the sulphate of soda. They are less active than the Püllna water, and are, further, of an alkaline nature.

In cases of constipation where a very strong agent is required, recourse must sometimes be had to croton oil.

Enemata are in much more common use in France than with us. An enema of tepid water or weak gruel often very effectively unloads the larger bowel, and has

the advantage of not producing the slightest general discomfort. The addition of a table-spoonful or a couple of table-spoonfuls of common salt increases its efficacy. Castor-oil and other aperients, also, are sometimes advantageously employed under the form of enemata.

The most suitable period for the administration of an aperient depends upon the nature of the agent employed, it being, as a rule, desirable to avoid disturbing the patient by causing the bowels to be moved during the night. For the saline purgatives, which are not long in producing their effect, the best time is the morning; and if taken on an empty stomach, as the first thing on rising, their utmost efficiency is elicited. The ordinary form of aperient pill is customarily taken at bedtime, and in the usual way is followed by an action the next day. In habitual constipation a pill of moderate strength, taken with the food and repeated daily as occasion is found to require, produces the best effect. The cathartic, traversing the intestine with the alimentary matter, forms the means of stimulating the glands and muscular fibres to an increased degree of activity. Such a pill—dinner-pill, as it is popularly styled—may advantageously consist of two or three grains of aloes, or compound rhubarb or compound colocynth pill, with a grain of capsicum. The gourmand has recourse to his dinner-pill to hasten the transit of the ingesta through the alimentary canal; and so, to escape the evil consequences that might otherwise arise from his indiscreet indulgence.

The contents of the colon, as the result of prolonged retention, may become of so hard a consistence, that purgatives administered by the stomach, and even pur-

gative enemata, may fail to procure a dislodgment and mechanical means require to be had recourse to, to effect their removal. It is especially amongst aged females of a lax or flabby habit of body that such extreme instances of constipation are most likely to occur. The patient may have no idea that the bowel is impacted in this way, from the circumstance that some action has been previously occasionally obtained; and the practitioner requires to be on the alert to guard against mistaking the fæcal accumulation in such cases for an adventitious growth, as such before now, through insufficient investigation, has been done.

The extract of nux vomica and compound galbanum pill (Pilula Assafœtidæ composita, as it is now called in the 'British Pharmacopœia') often form useful adjuncts to an aperient; and much assistance is frequently rendered towards the relief of costiveness by medicinal agents that are calculated to improve generally the tone of the system—by a course, for instance, of ordinary tonics. The cold shower- or sponge-bath in the morning, and exercise—especially horse exercise—form measures that often tend considerably to help the action of aperients in regulating the bowels. Friction applied to the abdomen forms also a measure that may sometimes afford assistance. With a large and pendulous abdomen benefit is obtained from wearing a belt, for the purpose of affording artificial support.

Electricity has been sometimes had recourse to in cases of constipation. Dr. Abercrombie relates a case in which, it seems, the employment of galvanism proved very successful. The bowels had resisted the influence of the strongest purgatives, except when assisted by repeated and strong injections. Galvanism was applied

to the part of the abdomen which was hard and tense, and was almost immediately followed by a copious evacuation from the bowels. Continued daily for about ten days, it was uniformly followed by the same result. After a few minutes' application there usually commenced a commotion, with a rumbling noise in the abdomen, this being soon followed by a copious evacuation.

Assistance is given in the treatment of constipation by attention to the diet. Fresh, or succulent vegetables and fruits are the most relaxing of all kinds of food. Bread, biscuit, rice, hard-boiled eggs, and meats and fish that have been salted and dried are, on the other hand, to be classed as the most astringent. Bran is of an indigestible nature, and a slight irritant to the alimentary canal. Hence, the explanation of the influence of brown bread in tending to produce a relaxing effect upon the bowels. In an irritable state of the digestive tract, indeed, it may so stimulate the glandular and muscular structures of the canal as actually to produce diarrhœa. Experience shows that the consumption of brown instead of white bread will often just suffice to obviate the occurrence of constipation.

Constipation is in many, perhaps in the majority of instances, primarily induced by a want of attention to the observance of regularity in the action of the bowels. It is quite as essential to health and comfort that regularity should be observed in the discharge of the egesta as in the consumption of food. No part of the system can be more thoroughly brought in subjection to the influence of habit than that connected with the function of defæcation. A daily habit of evacuating the bowels at a stated period having been established, as the time

comes round a feeling of desire is experienced; and, should the accustomed respondence fail to be permitted a sense of discomfort will for a time be induced.

The habit in question should be begun with and enforced by parents and nurses from the earliest period of childhood. Where neglect is allowed to prevail, the bowel, becoming accustomed to over-distension, fails to give the natural warning until accumulation has taken place to an extent sufficient to render the process of defæcation unnaturally difficult. As time wears on, matters gradually become worse and worse, a host of secondary evils are induced, and ultimately the bowels refuse to act without some kind of artificial stimulus being supplied.

In such a case, a habit of regularity may still in the generality of instances be acquired, but determination and perseverance on the part of the individual are needed for the purpose. The attempt should be made and renewed every day at the same hour, whether the inclination exist or not, and likewise whether the result be successful or not.

Thus, in the course of time it will with a fair amount of probability be found, that at the appointed hour the proper desire arrives spontaneously, and leads to the easy accomplishment of that which is required by nature to be performed. The assistance of an occasional enema or of a mild aperient course may be found necessary at first to get a movement of the bowels produced.

ON ARTIFICIAL DIGESTION AS A MEANS OF DISSOLVING MEAT FOR PRODUCING AN ARTICLE OF NOURISHMENT FOR THE INVALID.

In beef tea, broths, and the extracts of meat prepared in the ordinary way, we have physiologically a very imperfect representation of an article of nourishment. Just those very principles of the meat, viz. fibrine and albumen, which constitute its special blood- and tissue-forming elements, and give to it its nutritive value, are left behind as insoluble products. The preparation contains the salines with the various extractive principles, a considerable proportion of which, there are grounds for believing, consist of products of partial decay—materials in course of retrograde metamorphosis, that are of no use as nutritive agents. Taking the extract of meat, for instance, prepared according to Liebig's process, the small quantity of product which he says ought to be obtained (thirty-four pounds of fresh meat yield, he states, only one pound of extract) shows how completely the bulk, or substance of the meat, which constitutes its real nutritive portion, must be rejected. If it be a nutritive article that it is desired to obtain from the meat, it cannot fail to be wrong in principle to adopt a process of preparation

that is attended with the rejection of just that portion which ought to be present.

Having frequently seen how effectually meat can be dissolved by the process of artificial digestion, I have long wondered that it has never been turned to practical account for the purpose, and have felt convinced that some day or other the time must arrive for it to be so.

Mr. Darby, of the firm of Messrs. Darby and Gosden, chemists and practical pharmaceutists, of 140, Leadenhall Street, London, to whom many months ago, during some interviews I was having with him upon the subject of a new kind of food for the diabetic, I communicated the views I have expressed, at once acted upon my suggestion, and has now succeeded in producing a a material of such a character as to give me grounds for thinking that the attention he has devoted to the matter bids fair to yield a fruitful result.

In the process of procedure adopted the same solvent menstruum that is employed by nature for dissolving meat constitutes that which is made use of. A liquid is prepared containing the organic digestive principle with the appropriate quantity of acid. The hydrochloric is the acid used; and, this being subsequently neutralised with the carbonate of soda, after it has served its purpose, the chloride of sodium or common salt is left in the product. About four hours is the time required, under the most suitable conditions, for solution to be effected. Filtration, it is found, leaves a residue amounting only to about one tenth of the weight of the lean meat that has been taken. This residue is of a greasy nature, and doubtless consists chiefly of fat, which forms a principle that, as is well

known, does not yield, under physiological circumstances, to gastric digestion.

The product obtained when the filtered liquid has been reduced to the consistence of an ordinary extract equals, roughly speaking, about a third of the weight of the meat, in a fresh and lean state, employed. The fibrine and albumen of the meat are both present, and, it is to be observed, present in such a form as to be ready at once for absorption. Having being dissolved in the same kind of way as they are in the living system preparatory to absorption, no action is required to be performed by the stomach. Hence such a product is peculiarly adapted to form a source of nourishment where, from any cause whatever, the digestive powers are in an enfeebled condition.

The effect of the natural process of digestion is not only to dissolve the nitrogenized alimentary principles, but also to transform and render them diffusible. By virtue of the property of diffusibility thus acquired, they can pass, in compliance with the physicial laws of osmosis, and without the exercise of any special vital absorbent action, from the alimentary canal into the circulatory system. That the process under consideration not only dissolves but likewise places the alimentary principles in the same diffusible state, has been reduced to demonstration by the results obtained in the experiments with the product, that have been kindly undertaken for me by Mr. Dickson, an old pupil of Guy's Hospital.

On account of the diffusible state in which the alimentary principles exist, absorption may also be reasonably looked for when the product is introduced into the rectum under the form of an enema.

Some specimens that have been sent to me by Mr. Darby have been taken by patients at Guy's Hospital, and, I am informed by Dr. Steele, the superintendent, have met with approval. Its solution, it must be said, does not make quite so agreeable a liquid to take by itself as beef tea, but it is susceptible of being rendered palatable by flavouring, and may be added to beef tea, broths, arrowroot, or any other kind of food to increase their nutritive properties. One tablespoonful of the product about corresponds to two ounces of fresh lean meat.

It is right to state that whilst the pages of this volume have been going through the press I have been favoured by Dr. Marcet with a copy of the pamphlet he has just published 'On a New Process for preparing Meat for Weak Stomachs.' I here learn that the same idea has been passing through Dr. Marcet's mind as through my own; but, whilst I have been looking to the production of a material for use in a state ready prepared, Dr. Marcet recommends that the process of preparation should be carried on in the patient's house as the article is wanted, just as is ordinarily done in the case of beef tea. For my own part, I feel that such precision is required in the method of procedure as to render it hardly to be expected that the process will be found to be susceptible of being successfully carried out in the hands of the public.

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